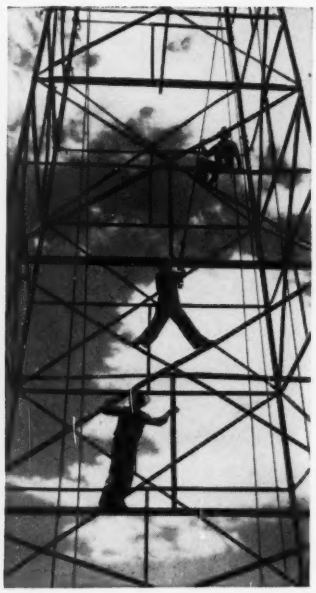
tech engineering news

may 1953

Only STEEL can do so many jobs so well



OPPORTUNITIES WITH U. S. STEEL

If you're thinking about what you're going to do after graduation . . . if you're interested in a challenging, rewarding position with a progressive company . . . then it will pay you to look into the opportunities with United States Steel. Your placement director can give you more details, or we'll be glad to send you the informative booklet, "Paths of Opportunity." United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

Stainless steel walls mark the handsome skyscrapers of Pittsburgh's Gateway Center. Panels are made of corrosion-resistant Stainless Steel, backed up with lightweight concrete reinforced with welded wire fabric. These are attached to the building frame quickly and easily. Multi-story building walls go up with astonishing speed—in this project, at better than a floor-a-day rate. And because these wall panels weigh less, the weight of supporting structural members is also reduced, resulting in lower building costs.

They work high to dig deep. Steel derricks like this symbolize one of America's most vital defense treasures . . . oil. To help bring up the "black gold" from its ancient, miles-deep resting places, U. S. Steel makes drilling rigs, steel drill pipe, casing and tubing, cement, pumps, wire lines, and tough alloy steels for the drilling bits that can bite through the hardest rock.

Photo—Standard Oil Co. (N. J.)

Taking no chances is a good rule to follow on modern highways. Drive carefully—the life you save may be your own. This U·S·S American Multisafty Cable Guard saves many lives, too. Over 140 proving ground impact tests, using cars of all types, have demonstrated that this type of highway guard provides greater protection at high speeds.

MANUFACTURED FROM USS STEEL UNITED STATES STEEL

This trade-mark is your guide to quality steel

UNITED STATES STEEL

AMERICAN BRIDGE . . AMERICAN STEEL & WIRE and CYCLONE FENCE . . COLUMBIA-GENEVA STEEL . . CONSOLIDATED WESTERN STEEL . . GERRARD STEEL STRAPPING . . NATIONAL TUBE
OIL WELL SUPPLY . . TENNESSEE COAL & IRON . . UNITED STATES STEEL PRODUCTS . . UNITED STATES STEEL SUPPLY . . *Divisions of* UNITED STATES STEEL CORPORATION, PITTSBURGH
GUNNISON HOMES, INC. • UNION SUPPLY COMPANY • UNITED STATES STEEL EXPORT COMPANY • UNIVERSAL ATLAS CEMENT COMPANY 3-1092

One day of feeling better doesn't mean you're cured

EVER HAVE FLU, feel better, and go out too soon—only to have a relapse worse than the first attack?

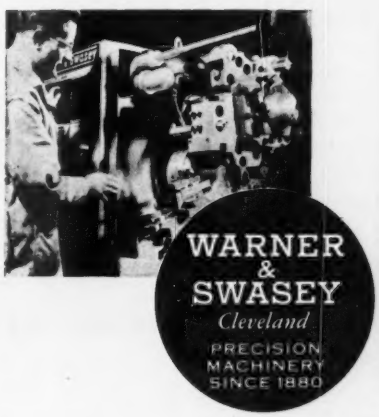
For years the world has been sick. "Something-for-nothing," Welfare State, Socialism, "more-pay-for-less-work"—the disease has different names at different times and places, but it's the same trouble—loss of energy, ambition, faith-in-yourself.

Now much of the world and especially this part of it is feeling better; we think we'll live—as this is written it looks as though more housing, lower prices, lower taxes, and most important of all, less war, are in prospect. BUT—

Don't let's take it too easy too soon. The fever of inflation and debt have wasted the nation's strength and substance which have to be built back. If we continue our tried and true American medicine of hard work, and add the convalescent tonic of thrift, we'll really recover. But as any doctor knows, this first surge of "feeling better" is the dangerous stage:

A relapse could kill us.

Warner & Swasey is always interested in talking future opportunities to young men of ability and character. Write Charles Ufford.



YOU CAN PRODUCE IT BETTER, FASTER, FOR LESS WITH WARNER & SWASEY MACHINE TOOLS, TEXTILE MACHINERY, CONSTRUCTION MACHINERY

Opportunities Unlimited

for all types of engineers

CHANCES are—if he has what it takes—a young engineering graduate will find at General Motors the career opportunity he's seeking.

And there are sound reasons why.

In the first place, General Motors makes so many different kinds of products, there is need for almost every type of engineering skill. These products range from automobiles and trucks to refrigerators, fractional horsepower motors and Diesel engines. GM defense contracts include shells, bombsights, range finders, tanks and gas turbine engines.

Yet, this great variety of work is widely distributed among GM's 33 manufacturing divisions, its 111 plants in 55 towns and cities throughout the United States. So although each division has its own engineering department, each can count upon the facilities of GM's central research and engineering laboratories.

It's this combination of big-time opportunity and local intimacy that fosters so many notable engineering careers at General Motors. In fact, many of the top positions at GM right now are occupied by engineering school graduates.

Why not think about this, as your time of decision draws near? Your College Placement Office can arrange for an interview with our GM College Representative the next time he visits your campus. Or if you prefer, write direct to us.

GM positions now available in these fields:

MECHANICAL ENGINEERING • ELECTRICAL ENGINEERING
METALLURGICAL ENGINEERING • INDUSTRIAL ENGINEERING
CHEMICAL ENGINEERING • BUSINESS ADMINISTRATION

Summer jobs available — for engineering undergraduates who want practical experience

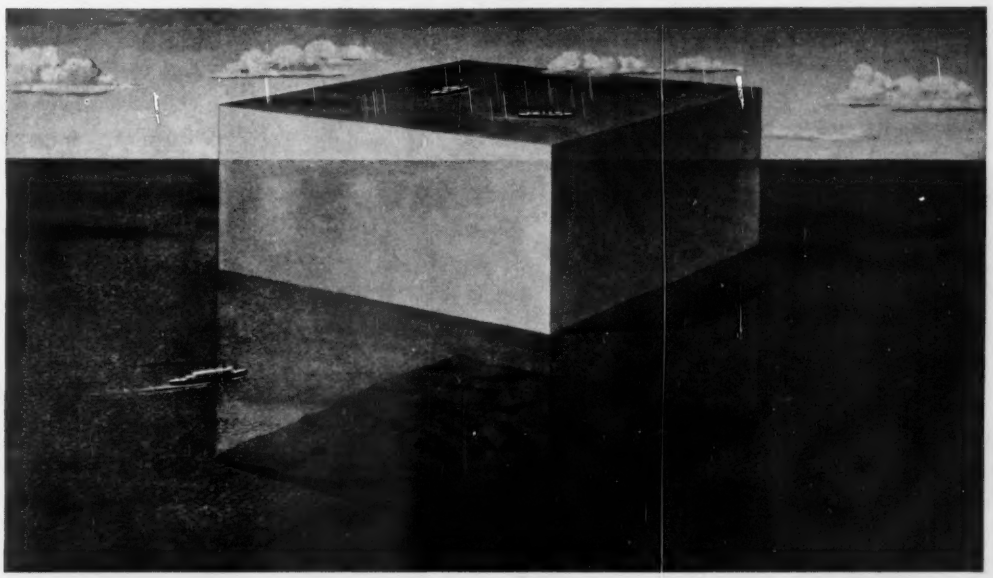
GENERAL MOTORS CORPORATION

Personnel Staff, Detroit 2, Michigan

DOW

THE SEA IS AN INEXHAUSTIBLE SOURCE OF AN IMPORTANT METAL

Each cubic mile of sea water contains six million tons of MAGNESIUM, the lightweight metal of so many uses



Today, when this nation is confronted with a crisis in our supply of many raw materials, it is of immense significance that the sea around us contains an almost unlimited supply of Magnesium. For Magnesium is light, strong, practical and versatile—the answer to many manufacturers' needs.

Dow began research on the extraction of Magnesium from brine over forty years ago. In 1941, at Dow's Freeport, Texas Plant, *the first commercial extraction from sea water was begun.* Dow pioneered in the production and development of Magnesium and its alloys and remains the leading producer and fabricator today.

Magnesium is only one of more than 600 chemicals produced by Dow. From Dow's many rapidly expanding plants throughout the nation flows an increasing abundance of chemicals and chemical products. Besides Magnesium, these include Industrial, Agricultural, and Fine Chemicals as well as Plastics.

Dow's Booklet, "Opportunities with The Dow Chemical Company," especially written for those about to enter the chemical profession, is available free, upon request. Write to THE DOW CHEMICAL COMPANY, Technical Employment, Midland, Michigan.

you can depend on DOW CHEMICALS DOW

tech engineering news

May 1953
Vol. XXXIV No. 8

Briefing the News 10

Kresge Hall 14
By Gary Kincaid, '56

Reaction at Work 18
By Jon C. Jansen, '56

Flea-Powered Communications 20
By Jerry Tiemann, '53

Storm in the South 22
By Bill Houston, G.

Editorial 29

Control in Digital Computers 36
By David Sternlight, '54

Escape ??? 42
By Ernest Schurmann, G.

The Ethical Dilemma of Science 48
By A. V. Hill

Science and Sciencibility 56
By Arnold Levine, '53

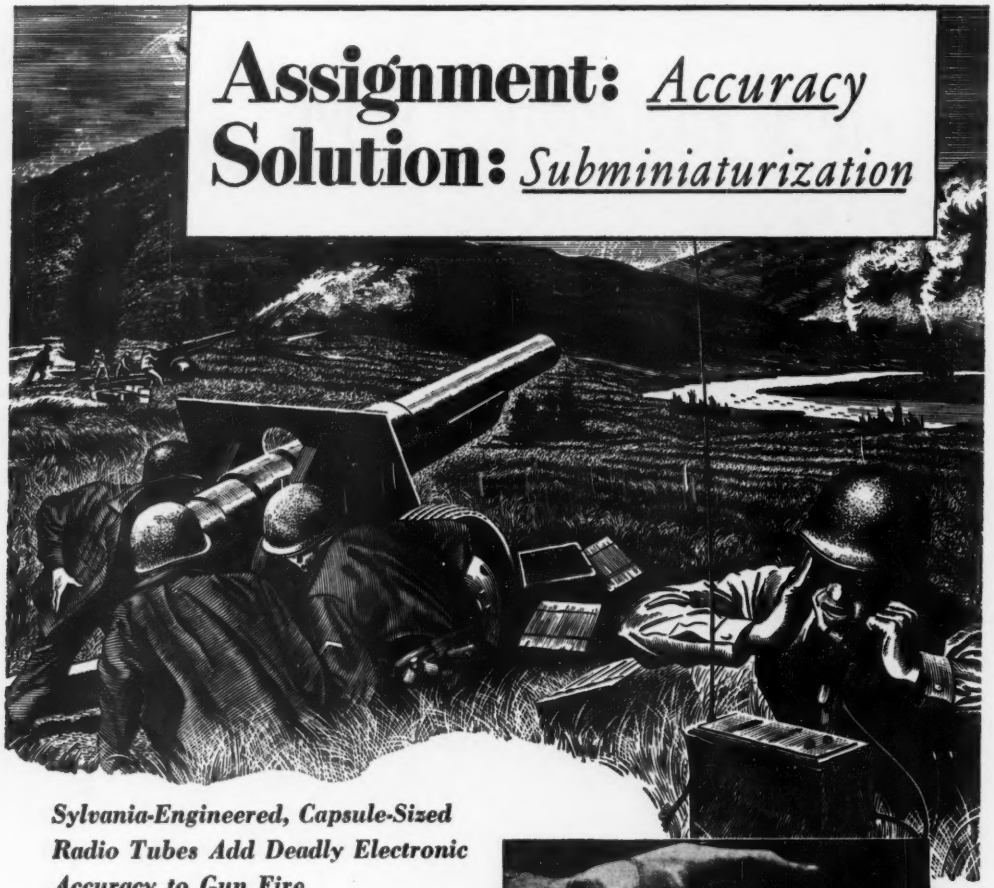
Cover Design by Paul Spreiregen, '54

FRONTISPIECE

Ribs of the City

Published monthly during the school year at Walker Memorial, Cambridge 39, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology. Entered as second class matter, at the Post Office, June 1, 1920, at Boston, Massachusetts under the Act of March 3, 1879. Copyright 1953 by The Tech Engineering News. Subscription per year $1.75. Foreign $2.50. One copy 25 cents.

Assignment: *Accuracy*
Solution: *Subminiaturization*



Sylvania-Engineered, Capsule-Sized Radio Tubes Add Deadly Electronic Accuracy to Gun Fire

"Needed: a high-performance radio tube—rugged enough to meet battle conditions — small enough for compact military equipment."

A tough job? — YES. But typical of Sylvania's advanced, vital engineering assignments whose solutions unlock doors to the future.

Finding answers to such problems is the basis of Sylvania's continuing growth and leadership. If that's the kind of engineering you're looking for—we're looking for you!

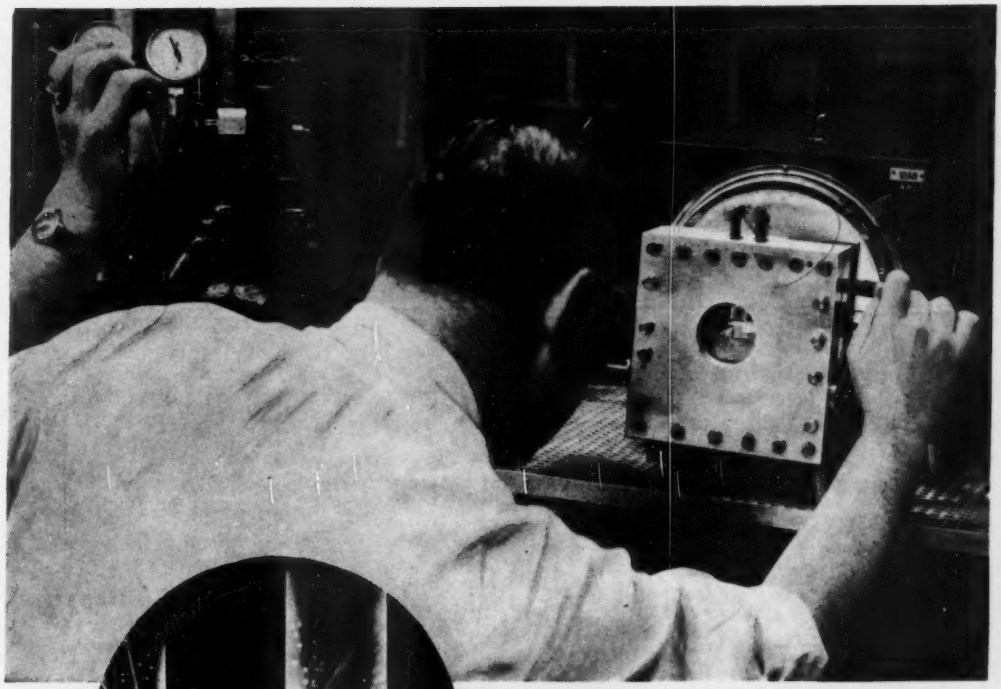
For information on Sylvania's program for graduating engineers—see your Placement office today—or write Supervisor of Technical Employment . . .

Typical Sylvania subminiature tube 1¼" long, pencil thin—heart of vital electronic equipment.

SYLVANIA

Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.

LIGHTING • RADIO • ELECTRONICS • TELEVISION



This Sperry engineer is applying the fundamentals of hydraulics to determine oil flow characteristics at high pressure. Here he introduces nitrogen to the hydraulic fluid in a complex valve to make flow patterns visible for study.

There's Job Diversity at Sperry

FOR THE GRADUATE ENGINEER!

Right now there are openings for...

- Aeronautical engineers
- Electrical engineers
- Electronic engineers
- Mechanical engineers
- Physicists
- Technical writers
- Field engineers for applied engineering

In each field you work with leaders on interesting projects vital to the nation's well-being—long-range projects with a future—projects that call for originality and fresh thinking.

You share in Sperry's prestige

You'll be proud to say you're a Sperry Engineer. Because, as a member of the engineering staff, you'll share in a forty-year reputation for leadership. Today Sperry is the acknowledged leader in the field of automatic controls for navigation. From Sperry's work in gyroscopics and electronics have come the Gyropilot* flight controller, Zero Reader* flight director, Microline* test equipment, radar, servomechanisms, computing mechanisms, and communications equipment.

Attractive locations

Long Island—A pleasant suburban atmosphere convenient to New York. Modern plant. Well-equipped laboratories. Excellent working facilities.

In the Field—There are excellent applied engineering opportunities in various sections of the United States and abroad.

Good working conditions

The way is clear for steady advancement. You are encouraged to continue your education while you earn. And liberal employee benefits are provided for all.

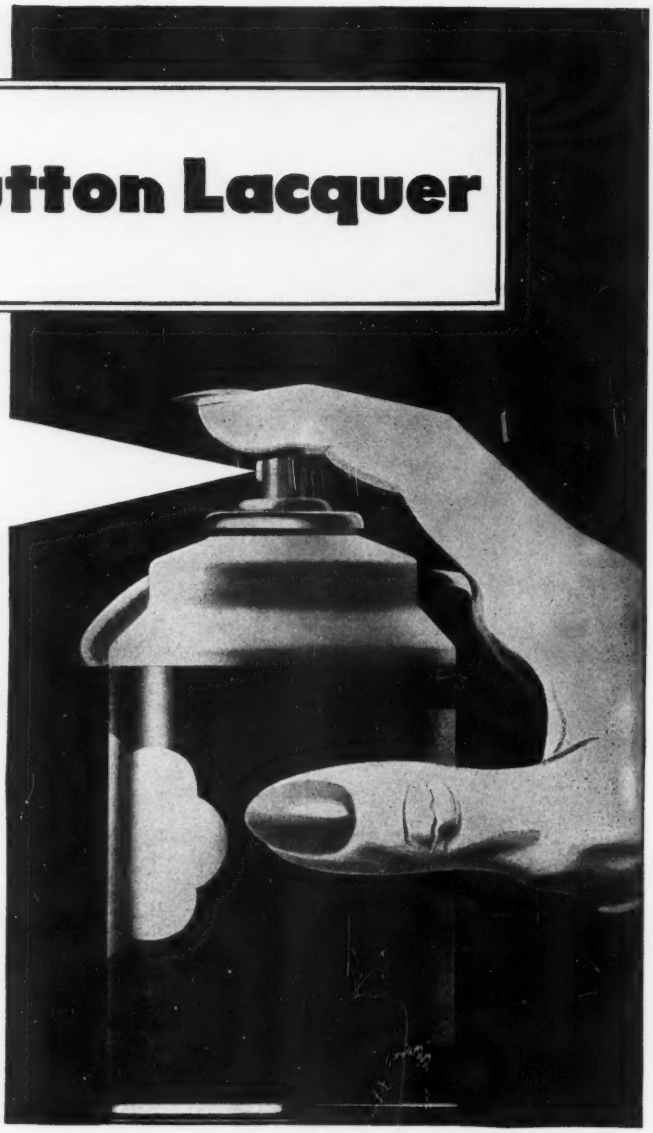
Check your placement office for dates when Sperry representatives will visit your school ...or write Sperry employment section 1 A 5.

*T. M. REG. U.S. PAT. OFF.

SPERRY GYROSCOPE COMPANY
DIVISION OF THE SPERRY CORPORATION

GREAT NECK, NEW YORK • CLEVELAND • NEW ORLEANS • BROOKLYN • LOS ANGELES • SAN FRANCISCO • SEATTLE
IN CANADA • SPERRY GYROSCOPE COMPANY OF CANADA, LIMITED, MONTREAL, QUEBEC

Push-Button Lacquer



CHEMICAL PROBLEM...

. . . a means of "touching up" furniture, automobiles, and household equipment that would be convenient, easy to do, and not messy.

SOLUTION . . .

. . . aerosol lacquers, made with nitrocellulose and resins produced by Hercules. These quick-drying sprays, readily applied at the touch of a finger, restore original color to any lacquered or baked enamel surface.

COLLEGE MEN . . .

This is but one example of the far-reaching chemical developments in which you could participate at Hercules—in research, production, sales, or staff operations. It suggests the ways Hercules' products serve an ever-broadening range of industries and end-uses.

Hercules' business is solving problems by chemistry for industry . . .

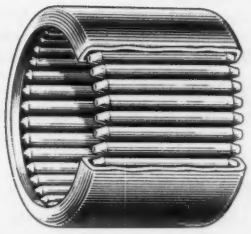
. . . soaps, detergents, rubber, insecticides, adhesives, plastics, paint, varnish, lacquer, textiles, paper, to name a few, use Hercules® synthetic resins, cellulose products, chemical cotton, terpene chemicals, rosin and rosin derivatives, chlorinated products and other chemical processing materials. Hercules® explosives serve mining, quarrying, construction, seismograph projects everywhere.

HERCULES

HERCULES POWDER COMPANY Wilmington 99, Delaware
Sales Offices in Principal Cities

The Torrington Needle Bearing

. . . shaft hardness determines effective load capacity



The economy of the Torrington Needle Bearing is due in part to the fact that the shaft usually serves as the inner race. Thus, since the shaft is an integral part of the bearing, its load capacity limits the capacity of the bearing assembly. In order to obtain the full rated load capacity of the Needle Bearing, it is necessary that the shaft be at least surface-hardened to the equivalent of Rockwell C-58.

Loads and Speeds Related to Shaft Hardness

Because of material or design limitations, it is sometimes desired to run Needle Bearings on shafts softer than the recommended Rockwell C-58. This can be done safely providing the bearing loads and speeds are not too severe. However, the capacity of the bearing assembly is only as great as the load capacity of the shaft, regardless of the rated load capacity of the bearing as indicated in the catalog. The shaft capacity decreases very rapidly as the surface hardness is reduced below the recommended Rockwell C-58 minimum hardness.

Figure 1 shows this very clearly. It can be seen that reducing the shaft hardness to Rockwell C-52 gives a resulting load factor of .5. In this case, the catalog rating must be multiplied by .5 in order to obtain the true capacity of the bearing assembly.

Unheat-treated, cold rolled shafting will only carry 2%-3% of the bearing's rated load capacity.

The speed of the application is also important in determining proper hardness to assure satisfactory shaft life. The chart in Figure 2 illustrates this effect.

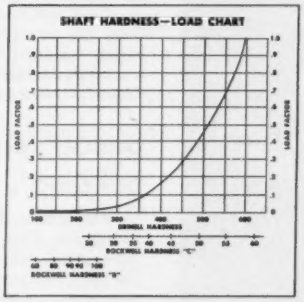


Figure 1. If the surface hardness of the shaft, its tensile strength, or the per cent of carbon is known, the load factor can be read either right or left from the intersection of the curve. The load factor, multiplied by the rated capacity of the bearing, will give the shaft capacity and the capacity of the application.

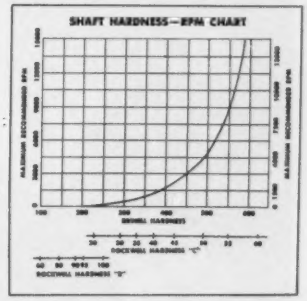


Figure 2. As the speed increases, it is desirable to increase the shaft hardness. For a given rpm, read across to the curve and down to the proper hardness. Conversely, if hardness is known, read up to the curve and across to the maximum rpm for that shaft.

Hardened Inner Races Available

When it is either impossible or impractical to harden the shaft, it is necessary to use an inner race which will provide the required surface for Needle Bearing operation. Inner races are available for all sizes of Needle Bearings. When used, inner races should be securely fastened to the shaft by clamping against a shoulder, by snap ring, or by press fit.

When designing Needle Bearings into a piece of equipment where shaft hardness is a question, the economics of using inner races as compared to a properly heat treated shaft should be carefully analyzed. When all factors such as inner race cost, securing devices, and actual assembly time are considered, it is usually found more economical to heat treat the shaft.

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON NEEDLE BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

briefing the news

"Air sieve" . . .

Superfine powders, composed of uniform particles so small that more than a thousand could line up single file across the head of an ordinary pin, are being separated here with a moving air stream, using a device developed by Dr. Lewis R. Koller. One application of such powders, more than ten times as small as any which can be sifted through standard sieves, could be to

increase detail and brilliance of pictures shown in television receivers, he said.

According to Dr. Koller, the finest sieve commercially available has about three hundred twenty-five wires to the inch and will pass all particles smaller than about a two-thousandths of an inch in diameter. Finer sieves are very fragile and difficult to use. With Dr. Koller's "air sieve" there is no wire screen. The original powder, of particles of assorted sizes, is blown upwards through a vertical seven-foot glass tube, four inches in diameter. All the powder is lifted, but the smallest grains rise highest and are blown into a container at the top.

In using the device, technically termed an "elutriator," the original mixed powder is placed in a flask at the bottom and shaken mechanically. Then the air is gradually turned on, the speed being adjusted with the aid of a flow meter. At first, only the finest particles, which may be less than a ten-thousandth of an inch in diameter, reach the top. Here they pass through a tube that bends over to the side, and into a small collecting vessel. After this is removed and replaced with another such vessel, the air velocity is increased. Then larger grains, perhaps from one to two ten-thousandths of an inch in diameter, are collected. Repeating this process several times, with still higher air speeds, the original unclassified powder may be sorted out into uniform samples.

A possible application of these ultrafine powders is in television picture tubes. If the luminescent coating inside the face, on which the picture appears, is very thin, said Dr. Koller, greater brilliance may be obtained. The finer and more uniform the powders from which the coating is prepared, the thinner the coating may be.

Old ammunition reclaimed . . .

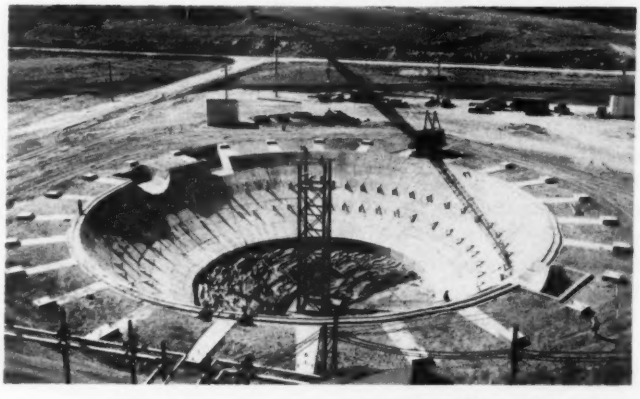
The Ordnance Ammunition Center of the U. S. Army, has purchased mouth-annealing equipment for installation at eight locations throughout the country in a dollar-saving program of reclaiming old ammunition of 40-, 75-, 76-, and 90-mm. calibers.

The purpose of the program is to reload shells that have become unreliable because of age. To reclaim the outdated shells, the projectiles and powder are removed from the cartridge cases and the mouth of the brass casing softened by induction annealing. This insures a snug fit against the grooves of the projectile when the cartridge cases are refilled.

Saucer foundation for spherical building . . .

The saucer-shape foundation for the two hundred twenty-five-foot steel sphere that is to house a nuclear submarine power plant being built by the Atomic Energy Commission for the Navy has been completed, and work on assembling the hull of the land-based prototype submarine is underway. Known as the Submarine Intermediate Reactor (SIR), this project is under the direction of the Knolls Atomic Power Laboratory. The reactor, and the sphere enclosing it, are being built on a four thousand acre site at West Milton, about eighteen miles north of Schenectady.

The spherical design of the reactor building was adopted to give additional protection to operating personnel and to offsite areas during test operations beyond the many safety controls of the reactor itself. Similar structures are widely used in the chemical and



to the

ELECTRICAL ENGINEER

or

PHYSICIST

with an interest in

RADAR

or

ELECTRONICS

Hughes Research and Development Laboratories, one of the nation's leading electronics organizations, are now creating a number of new openings in an important phase of their operation.

Here is what one of these positions offers you:

THE COMPANY

Hughes Research and Development Laboratories, located in Southern California, are presently engaged in the development and production of advanced radar systems, electronic computers and guided missiles.

THE NEW OPENINGS

The positions are for men who will serve as technical advisors to government agencies and companies purchasing Hughes equipment—also as technical consultants with engineers of other companies working on associated equipment. Your specific job would be essentially to help insure successful operation of Hughes equipment in the field.

THE TRAINING

On joining our organization, you will work in the Laboratories for several months to become thoroughly familiar with the equipment which you will later help users to understand and properly employ. If you have already had radar or electronics experience, you will find this knowledge helpful in your new work with us.

WHERE YOU WORK

After your period of training—at full pay—you may (1) remain with the Laboratories in Southern California in an instructive or administrative capacity, (2) become the Hughes representative at a company where our equipment is being installed, or (3) be the Hughes representative at a military base in this country—or overseas (single men only). Compensation is made for traveling and moving household effects, and married men keep their families with them at all times.

YOUR FUTURE

In one of these positions you will gain all-around experience that will increase your value to our organization as it further expands in the field of electronics. The next few years are certain to see large-scale commercial employment of electronic systems. Your training in and familiarity with the most advanced electronic techniques now will qualify you for even more important future positions.

How to apply:

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Scientific and Engineering Staff
Culver City, Los Angeles County, California

See your Placement Office for appointment with members of our Engineering Staff who will visit your campus. Or address your resumé to the Laboratories.

petroleum industries, but the West Milton sphere will be the largest ever constructed. In the remote event that simultaneously all other controls failed, the resulting release of radioactive material would be contained in the sphere which will have a net "free" space of more than five million four hundred thousand cubic feet.

The outer periphery of the building will be seven hundred feet. The sphere will rest on the concrete saucer just completed which is two hundred feet in diameter. A ring of steel columns set on concrete outside the structure and reaching to the middle of the sphere will give further support to the building. Welded steel plates will make up the skin of the ball. The plates will be hoisted into position by a derrick mounted on top of a temporary central steel tower.

Every weld in the structure must be X-rayed to assure that there are no leaks. To do this on the bottom, a four-foot space is provided temporarily between the base of the sphere and the concrete saucer. After testing is completed, this space will be filled with concrete and aggregate. Inside, the concrete floor on which the reactor will rest will be slightly above ground level and the well of the saucer beneath the floor will be filled with compacted mixture of aggregate and earth.

As soon as the columns are in place, the first ring of plates will gird the sphere at its center and assembly will proceed both upwards and downwards. Meanwhile the hull of the submarine will be assembled just outside the building and when the latter is completed and tested, the hull will be skidded into the huge ball through a special wall section and the sphere again sealed.

The Submarine Intermediate Reactor is one of two nuclear science approaches being made to the problem of utilizing atomic fuel for underwater ship propulsion. The other is incorporated in a project at the National Reactor Testing Station in Idaho. The reactor designed for the West Milton site will use liquid sodium metal to take the heat out of the reactor core and into an exchanger or "boiler" where water will be converted to steam. The steam will then drive the turbines that propel the submarine.

Auto wheel balancer . . .

A new mercury-reactor attachment for automobile wheels will combine several advantages to give motorists smoother riding comfort. This is accomplished by a set of four discs which can be attached to the wheels of any car. Each disc has a number of radially positioned cylinders containing mercury, and is mounted inside the wheel rim around the axle. The discs are attached to the same lugs which hold the wheels and are covered by the hub caps.

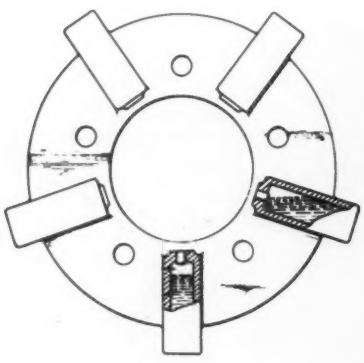
The mercury-loaded discs eliminate the need for balancing weights on car wheels. Weights have never been fully satisfactory because the balance is lost every time a tire is changed or a wheel transposed. Furthermore, uneven wear on tires soon offsets the balance. With the new discs, however, the wheels are constantly dynamically balanced regardless of other factors. This not only produces a smoother ride, but also has proved in tests to extend greatly the life of the tires, because they are made to wear evenly.

The tremendous centrifugal force built up in a rotating car wheel magnifies any unbalance and develops a hammering action. The mercury disc builds up an equal counter force to this and completely cancels the unbalance.

Another important function of the mercury weighted discs is their vertical shock-absorbing action. The mercury reacts instantly against chatter and shocks due to road roughness before they reach the axles and thereby save considerable wear on chassis points. All other cushioning devices on the car pick up the shock after it has passed the wheel.

The mercury stabilizers also control lateral action. Since the mercury is free to move from side to side, as well as up and down in the chambers, any tendency of the wheels to wobble or shimmy is countered, saving wear on wheel bearings and king pins.

The gyroscopic force built up by the mercury also stabilizes the car's forward line of motion. This helps to straighten wheels out after turns, eliminate drifting, and prevent side-hopping on rough roads.



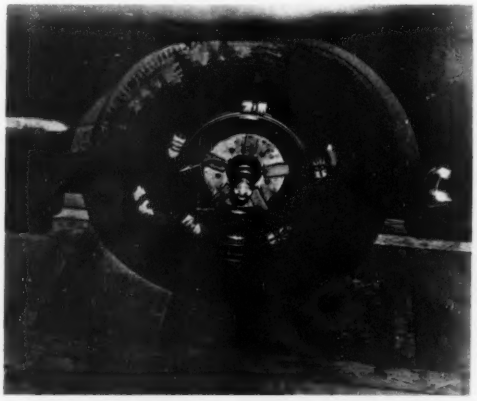
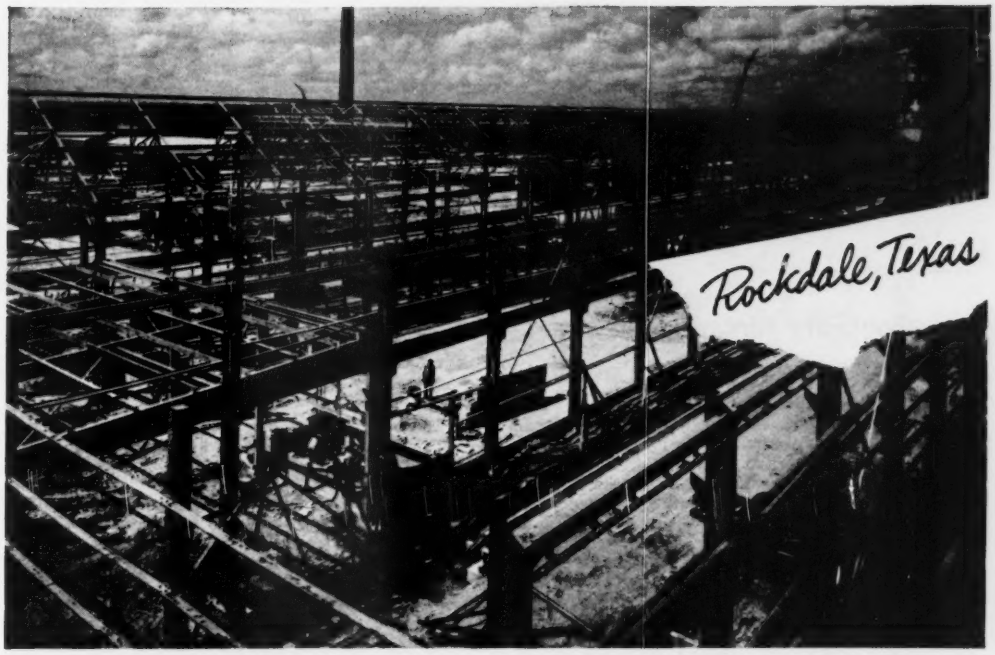


Diagram at left shows wheel stabilizer with mercury filled chambers and holes which fit over lugs. Picture at right shows the mercury disc mounted inside wheel rim. A flashlight is attached to the hub to produce a light streak in night road test. Batteries have been carefully balanced around the rim to light the flash. The car was then driven over the rungs of a long ladder to simulate the effect of a rough washboard road.

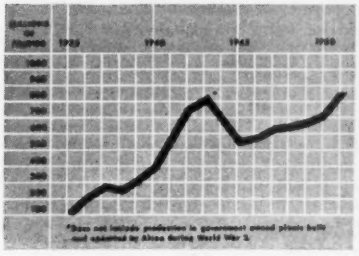


Is part of your future being built here?

Here you see the beginning of another addition to Alcoa's expanding facilities. This plant, at Rockdale, Texas, will be the first in the world to use power generated from lignite fuel and will produce 170 million pounds of aluminum a year. This and other new plants bring Alcoa's production capacity to a billion pounds of aluminum a year, four times as much as we produced in 1939. And still the demand for aluminum products continues to grow. Consider the opportunities for you if you choose to grow with us.

What can this mean as a career for you?

This is a production chart—shows the millions of pounds of aluminum produced by Alcoa each year between 1935 and 1951. Good men did good work to create this record. You can work with these same men, learn from them and qualify yourself for continually developing opportunities. And that production curve is still rising, we're still expanding, and opportunities for young men joining us now are almost limitless.



Ever-expanding Alcoa needs engineers, metallurgists, and technically minded "laymen" for production, research and sales positions. If you graduate soon, if you want to be with a dynamic company that's "going places," get in touch with us. Benefits are many; stability is a matter of proud record; *opportunities are unlimited.*

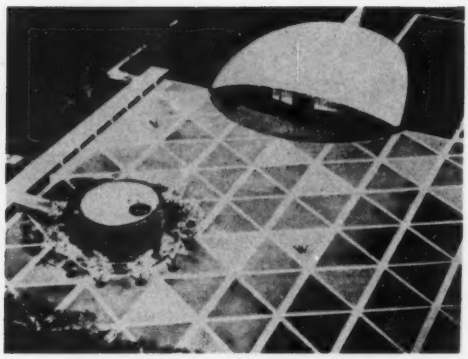
For more facts, consult your Placement Director.

Alcoa Aluminum

ALUMINUM COMPANY OF AMERICA

kresge hall

Experiment in Function and Design



By Gary Kincaid, '56

The first step toward bettering MIT's recreational facilities has been approved, and construction should be started before the end of this term upon Kresge Hall, the long-needed auditorium. As this was going to press, the bids from the contractors were in, but the Institute was trying to cut down costs some before awarding the contract. The administration has set a goal of June 1954 for the completion of Kresge Hall.

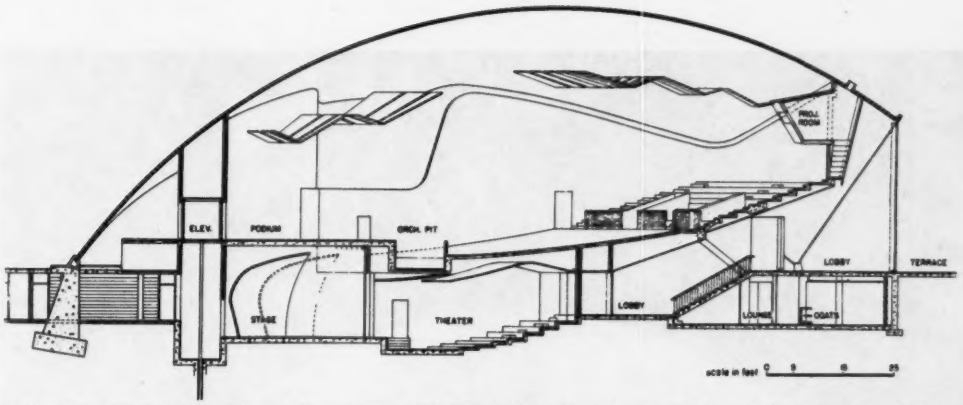
Along with the auditorium, MIT plans to build a chapel, but so far plans have not been given the final approval. As seen in the accompanying pictures, the complete layout is very unique to say the least. The auditorium is a concrete shell dome, one-eighth of a sphere, supported at three points by heavy abutments with windows forming the remaining vertical wall space. The present plan under consideration for the chapel has a brick cylindrical building with no windows in it. Light will be furnished upon the altar by a circular skylight in the ceiling which allows the light to be reflected upon the altar only. The effect will be magnified by stainless steel wires forming a semi-circle around the altar and extending from the floor to the skylight. These will glisten from the light above and the altar will appear to be surrounded by silvery rays. This brick tower rests on irregular shaped and spaced arches, which in turn rest upon a moat. Light will be reflected from the water in the moat, up through the masonary arches and around the walls so that the worshipper sees a pattern of alternate shade and brightness on the walls.

Although the auditorium is the first of its kind, MIT is not intending to sacrifice cost for function. The plan contains for the square footage, a maximum of efficient usable area and is available for a great variety of uses. The plans for the auditorium have been under consideration for over two years with all phases of construction and usage having been studied. When the Institute first proposed the new auditorium in late 1950, a committee was appointed to study its usage requirements from the standpoint of MIT. This committee was composed of Professor H. R. Bartlett, representing the Humanities department and non-staff lecture usage; Professor R. H. Bolt, drama usage; Professor W. H. Gale, stall lectures and functions; and Professor K. Liepmann, music usage. The general purpose of the committee was to study all the potential uses of the building and to prepare a set of architectural program requirements to be used as a guide for the architects. Over a year was spent preparing this report, during which time many people who would be connected with the use of the proposed auditorium were contacted to get their opinions on what was actually needed. During the study, many trips were made to visit other auditoriums to get ideas and a complete pseudo-schedule for the auditorium was drawn up for a six-month period listing all the organizations that would want to use the Hall.

Since MIT is not a drama, music, or liberal arts school and is not intending to become such in the immediate future, it was decided to make the building as compact a unit as possible, but still provide for as many of the present needs as possible. The committee set forth the following requirements for the inclusion into the plan: (1) auditorium seating about twelve hundred, reducible to about half size by a drop ceiling, (2) chapel with about seventy-five seats, small theater seating three hundred, (4) five rehearsal rooms of varying sizes, (5) four practice rooms also of varying sizes, (6) a lounge of seven hundred square feet, (7) a green room, (8) suite of offices for management, music, etc., (9) dressing rooms, (10) construction facilities, and (11) ample storage space (about twenty-eight hundred square feet).

When Saarinen's preliminary drawings came back to the administration for inspection much was to be desired in the way of facilities, but after a year more of exchanging ideas, the present plan was agreed upon. Now that the bids are in and too high, more changes might have to be made, though.

Included in the present design (see accompanying pictures) are the fundamental desires and as many of the extras wanted as possible. The main auditorium will hold twelve hundred, but it is not possible to partition off any part of it. You will enter the building from the Massachusetts Avenue side into a lobby, then directly up a ramp to the auditorium. The auditorium seating is compared to that of a stadium with its rising seats and no balcony. As you approach the building, you will be able to see the underside of the auditorium floor showing the raise in elevation. The inside of the auditorium will be fairly plainly decorated but not drab. The walls will be vertical-grained paneling running all the way around to the back. On the back wall there will be the same wood stripping, but there will be space between the boards to allow sound to enter and be deadened. The side paneling also serves to cause sound to be reflected back out into the auditorium. The auditorium does not contain the regular proscenium, but is built much like an open air theater. This tends to bring the performers right out into the audience. On the right side of the hall in front, there is a place for a pipe organ and symmetrically placed on the other side is a place for a full choir. Directly in front of the stage is a small orchestra pit which can be either used to extend the size of the stage or for extra seating.



Section view of Kresge Hall taken from center of building. Floor between auditoriums to be sound-proofed to allow usage of both at once. Notice the acoustical baffling on ceiling of main hall.

The present plan calls for upholstered seats that automatically rise when not occupied. These special seats are produced in England and are acoustically treated. The presence of a person in any closed place causes sound waves to be absorbed and these seats take the place of a person. That is, the empty seat still causes the same effect as when the seat is occupied. The underside of the seat looks like a sound tile.

The ceiling is also acoustically designed. Slats, which show in profile in the section picture, will be suspended by wires from the concrete dome. These retard the concentrating effect of sound caused by the otherwise concave ceiling.

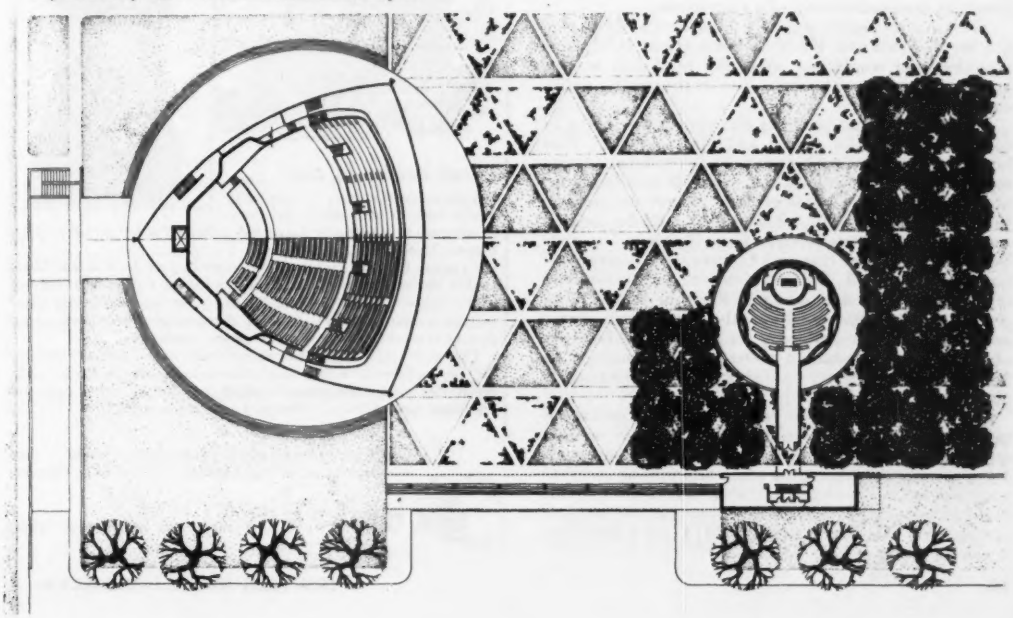
These baffles also cause some of the sound to be thrown back onto the stage which helps immensely in musical productions. The illusion produced is that of floating clouds as you will be able to see the dome between these slats. The slats are to be made of wood and covered with aluminum. The back of the stage is surrounded by a wooden cyclorama.

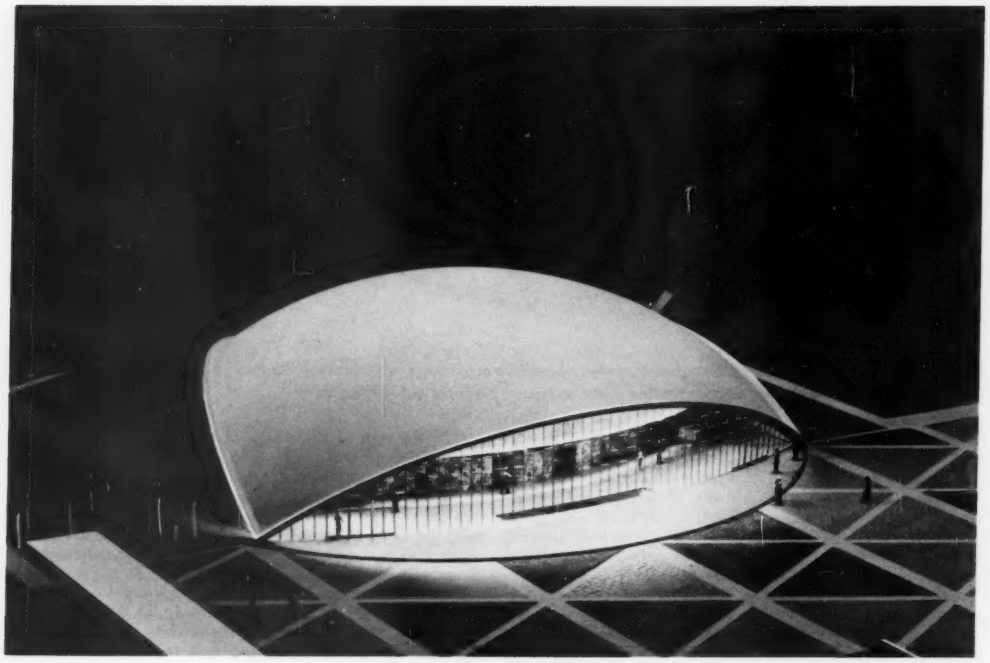
In the rear of the auditorium apparently suspended from the wall is a projection booth with all the equipment. There is also the usual public address system.

Directly below the auditorium will be a small theater seating about two hundred fifty. The stage has the same arrangement as the one above but contains no orchestra pit, etc. Flanking each side of the theater are two large combination rehearsal-storage rooms which will open unto the stage to allow scenery to be moved on and off the stage and also stored. These rooms may be opened to produce one long room. Also downstairs are the dressing rooms, lavatories, coat room, a suite of offices, and storage space for all the mechanical, heating, and ventilation equipment. Behind both stages is an elevator for transporting material from one level to another. At the back of the building is a ramp leading into the lower level and the elevator.

Both the ventilation and acoustical systems have been gone into with great detail and the building is so isolated acoustically that all the rooms may be used

Top cutaway view of auditorium and chapel.





Front view of auditorium.

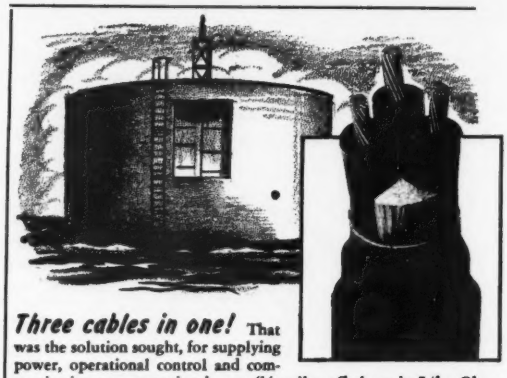
at once without the sound carrying from one part to the other. The entire building is to be completely air-conditioned, including the stages and lobby.

Cost of the auditorium will run around one million five hundred thousand dollars, the funds coming from a Kresge Foundation grant. The auditorium will cost about nine hundred dollars a seat compared to the usual eleven hundred dollars. The reduction in cost is introduced by the lack of need of a stagehouse.

The plan of construction of the spherical dome has not been settled yet, but a substantial rise in its construction cost would not affect the total cost to any appreciable extent. The dome is to be covered by a thin copper plating.

Another unusual phase of the plan is the plaza in connection with the chapel and Kresge Hall. This brightly colored triangular promenade produces a striking contrast to the rest of the Institute and has been blended with the auditorium and chapel to produce perfect harmony. The whole set-up will be located across Massachusetts Avenue from Building 7 so that Bexley Hall and the Harvard Co-operative Society will have to be removed. Present plans call for the building of a Student Union building in the near future to be placed just to the north of the auditorium-chapel arrangement, thus combining the recreational facilities of MIT. If the proposed underpass goes through on Massachusetts Avenue, a parking lot under the plaza is planned.

The administration was rather dubious about experimenting with the auditorium at first, for they wanted an auditorium more than they wanted to experiment. However, after studying the plans and finding out that they would be sacrificing nothing, they agreed. This building is bound to attract world-wide attention, and it is a fairly safe bet to say that MIT has a first that it can be proud of.



Three cables in one! That was the solution sought, for supplying power, operational control and communication to a pumping house 4½ miles off shore in Lake Okeechobee, Florida.

As usual, Okonite engineers were consulted on the problem. Their studies showed that it was possible to combine a three-fold function in one cable. This was accomplished by the use of Okolite high-voltage insulation whose electrical characteristics permitted carrier current to be superimposed on the power conductors.

The result was a single Okonite-insulated cable—steel-armored for the 4½ underwater miles, with a non-metallic sheath for an additional 2½ miles underground—which supplies not only power and operation control, but a communication circuit as well.

● ● ●

Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE insulated wires and cables

A MESSAGE TO
COLLEGE ENGINEERING
STUDENTS

from James H. Jewell, Vice-President
in Charge of Sales,
Westinghouse Electric Corporation

To the young engineer with an eye on sales

Let's agree that engineering is not always to be bounded by the quiet of the research laboratory or the roar of production machinery. Some of us like to meet people, to talk with them, to sell them on our ideas. That's why many young college men, like you, are choosing careers in sales engineering.

The sales engineer is a key man at Westinghouse—an important man in our future. Our products are essential to the defense and development of our country, and applying them to the needs of industry and the military requires men who are technically trained.

Westinghouse is a diversified company. Our products cover a wide range, including equipment for generation and utilization of electrical energy, aviation gas turbines, plastics and atomic power. Westinghouse is a growing company. Our expansion program has greatly increased our productive capacity to meet the growing needs of our nation. And here at Westinghouse, you are given every opportunity for personal development. Well-planned orientation and training, and programs for continued education and management development are integral parts of the Westinghouse plan. Yes, if your eye is on a sales career, you'll find the kind of opportunity you want at Westinghouse.

G-10850

YOU CAN BE SURE...IF IT'S
Westinghouse

For information on career opportunities at Westinghouse, consult Placement Officer of your University, or send for our 34-page book . . . *Finding Your Place in Industry.*

Write:
Mr. R. E. Davis
District Educational Co-ordinator
Westinghouse Electric Corporation
10 High Street
Boston 10, Massachusetts

reaction at work

A History of Jet Development

By Jon C. Jansen, '56

Jet propulsion is not a recent innovation, for it has been known for centuries. Many pioneers in science and engineering have experimented with various forms of jet propulsion and made devices utilizing this principle.

Probably the earliest use of jet propulsion was in the aeropile, which was invented over two thousand years ago by a Greek named Hero. The device consisted of a hollow iron ball filled with water and mounted on a horizontal axis. When the ball was heated, steam was emitted through two outlets, tangential to the surface of the ball, causing it to spin rapidly. It was a novelty, and there was no attempt made to employ it for practical purposes.

Later, in 1629, Branca invented a machine using jet power. In this machine, water was heated in a closed vessel and the steam thus produced was directed tangentially against a fanlike wheel. Actually it was a steam turbine whose power was transmitted by means of gears.

Sir Isaac Newton was also aware of the jet principle (which conformed to his third law), but did not experiment with it to any extent. "Newton's steam carriage," a vehicle propelled by a steam jet from a closed vessel, was designed some time during the eighteenth century after Newton's death. Nevertheless, it was attributed to him.

During the eighteenth century several of the many attempts to build a workable steam engine utilized the jet principle but met with little success. Little further work of any consequence was done until the beginning of the twentieth century, when the first attempt to build a jet aircraft was made. This was a design by Avery for a helicopter driven by steam jet propeller.

Little further progress was made until in 1928, a young Englishman named Frank Whittle became interested in jet propulsion while he was in college. In 1930 he took out his first patent on a jet engine using a gas turbine with radial compressors. It used gasoline for fuel and was intended to power an airplane. The British Air Ministry and the large airplane firms showed little interest in the project but with some private assistance Whittle got started. In 1936 he tested his first jet aircraft, which gave a poor performance. Tests in 1937 and 1938 gave little better results. By this time Whittle's work interested the Air Ministry enough to give him a contract with the Gloster Company. In 1940 he designed the Gloster E-28/29, which first flew on May 15, 1941 with encouraging results.

The Gloster Company, using Whittle's plans, continued work on jet planes and in 1943 came out with an experimental twin jet fighter, which first flew in March of that year. The test flights were successful and productions on the Meteor began in 1944. The Meteor saw actions against the German V-1 flying bombs and later as a tactical fighter in Northern Europe, though never in very large numbers. In November 1945, a Meteor set a world speed record of 606 m.p.h.

At the end of World War II, several other British jet fighters, powered by Whittle-type engines, made their appearance. Great Britain is continuing an intensive program of jet development and is today one of the leading nations in that field.

During the same period that Whittle was developing jet aircraft in Britain, Campani, an Italian aircraft designer developed a modified turbojet plane of conventional lines. It was the Caproni-Campani CC-2, which first flew in December 1941, from Milan to Rome averaging about 130 m.p.h. Campani also designed an "afterburner"; an auxiliary jet engine used in combination with the standard reciprocating engine. The Re. 2005, a plane employing this system, flew over 400 m.p.h. at an altitude of 33,000 feet. The Italian Air Ministry showed little interest in these experiments, thus preventing further Italian jet development.

On the other hand, the Junkers plant in Germany began to work on jets in 1936. The following year B.M.W. also started working on jets. Neither company made much headway until 1940 when the Junkers Jumo 004 and the B.M.W. 003 were produced. The first of many German jets, a prototype of the Me 262 was powered by two Jumo 211 Engines. After a long series of tests and a change to superior Jumo 004 engines the Me 262-A went into production. It was an all-metal twin jet fighter with slightly swept back wings having a top speed of 525 m.p.h. and a ceiling of 40,000 feet. A few of these planes saw action in the last days of the war.

The Germans also had begun work on a jet bomber and made the first tests in 1943. Production began a year later on the Arado 234 B. It was an all-metal twin jet reconnaisance bomber with a top speed of 470 m.p.h. Another plane, the Arado 234-c was a larger, heavier model powered by four B.M.W. 003 engines arranged in pairs.

Junkers also manufactured the Ju 287, a heavy jet bomber with either four or six B.M.W. 003 engines. Its top speed was 500 m.p.h., its range 1200 miles, and its payload five tons — an excellent performance. A unique feature of this plane was the 25° forward sweep of its wings.

The last of the German jet planes was the Heinkel 162. It was a single jet fighter with the engine mounted on top of the fuselage behind the cockpit. It was put into large scale production early in 1945 in underground factories and saw some actions before the war ended. The He 162 had a top speed of 490 m.p.h. and could stay aloft for about forty minutes.

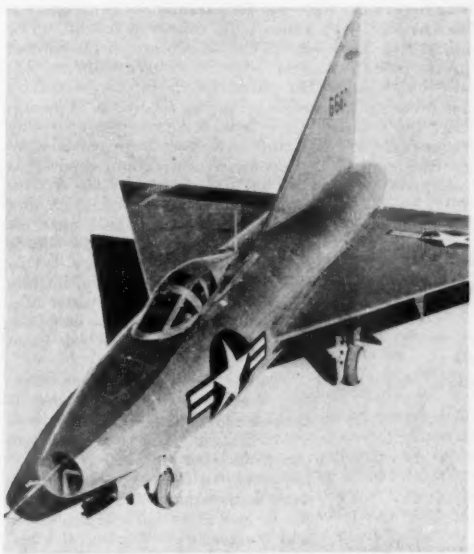
In the final stages of the war the German aircraft industries concentrated almost all their energy on the development of jet and rocket craft, desperately trying to find a means of stopping the Allied bombers. Haste and panic led to many mistakes, and changes of policy and personnel. As a result, there were many delays in development and production. In spite of this, the Germans reached a very advanced stage of development in jets, rockets, and guided missiles just before the war ended.

When the Russians overran Eastern Germany, they inherited the German aircraft industry, with its engineers, technicians and factories. This included the bulk

of the German jet plans which had moved east to escape Allied bombs. Until this time, the only jet project that the Russians had undertaken was the famous Katusha rocket launchers. However, they quickly became interested in jet development.

Early in 1946 the Russians installed Jumo jet engines in reworked frames of Yak-9 piston fighters and produced the Yak-15. Another model was the Mig-9 powered by two Jumo engines in the fuselage. Both of these were in the 550 m.p.h. class and had the lines of conventional fighters. They were by no means exceptional, but they gave the Russians their start in jet development. After that the Russians learned quickly; so quickly that the first models of the famous MiG-15 made their appearance late in 1947. This and subsequent Russian jets show strong German influence, especially in the swept-back wings and tail surfaces and in the arrangement of the power plant.

The United States didn't begin jet development until after General Arnold went to England in 1941 and saw jet progress there. He arranged to have a Whittle engine sent back here to be studied. Work on a jet plane started immediately, and an experimental model powered by two Whittle engines was tested in 1942. The next year General Electric began making jet engines based on the Whittle engine and using kerosene for fuel. The result of this work was the Bell P-59, a large heavy fighter powered by two G. E. jet units and having a top speed of 450 m.p.h. Production of this plane began late in 1944 but the P-59 never saw action and was converted to a trainer. In 1945 the Navy equipped the Ryan FR-1 "Fireball," a propeller fighter, with a jet afterburner. Its top speed was 300 m.p.h. on either engine or 425 m.p.h. with both engines. The first jet fighter to be adopted officially by the United States was the Lockheed F-80, which was designed in 1943 and went into production in 1945. It came too late for World War II but has performed well as a tactical plane in Korea. In addition to all these jet planes there are many others that have been undergoing development since the end of World War II.



Build a rewarding career as an S.S.White sales engineer...

Here is an opportunity for qualified engineering graduates to become associated with one of the country's leading manufacturers in a sales engineering job that will bring you in contact with top engineers in all branches of industry.

We are looking for graduate engineers who desire to utilize their engineering training in the sales and application of mechanical products in industry.

As an S.S.White sales engineer you will start at an attractive salary and be trained right on the job to undertake immediate responsibility.

Your opportunities for a lifetime career with S.S.White are unlimited. Promotions are made from within and your accomplishments will be quickly recognized and rewarded.

We will be glad to arrange an interview either at your school or in New York at the S.S.White Industrial Division offices. Write to Department C and include a snapshot of yourself and a brief resume of your education, background and experience.

THE S.S.White DENTAL MFG. CO. — INDUSTRIAL DIVISION
Dept. C. 10 East 40th St. NEW YORK 16, N. Y.

flea-powered communications

By Jerry Tiemann, '53

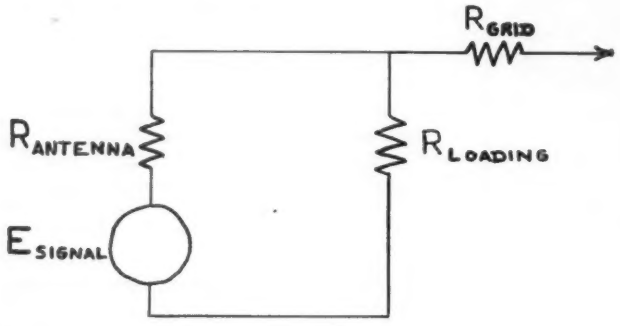
The development of transistors which can amplify with very good overall efficiency raises the question of what is the ultimate limit in the design of a miniature radio station. Now that power is no longer needed to heat filaments in vacuum tubes, the only remaining limitation is the amount of power which must actually be radiated from the antenna in order to carry on reliable communication. This amount depends on many things: the intended range, the degree of portability desired, the location, and the type of modulation (voice or Morse code) contemplated.

If a station is to be portable, too much directivity is undesirable because it is often inconvenient, if not impossible, to keep the antenna aimed exactly at the receiving station. Fixed stations, on the other hand, can concentrate all of the radiated power into a very narrow beam by using a multi-element antenna. This fact not only places a lower limit on the amount of power required for a portable installation, but also puts a lower limit on the size of the station. The power gain of an antenna in the forward direction is roughly proportional to the number of square wavelengths occupied by it, for if a certain amount of power is divided up among N portions of an antenna, each of which has the same radiation pattern, the radiation field from each one is divided by $N^{1/2}$ since the power is proportional to the square of the field intensity. The total radiation field from all N of these portions will therefore be $N^{1/2}$ times larger; and the power will be N times that radiated from one portion. But unfortunately the Law of Conservation of Energy applies, and the power radiated in all other directions is less than it was before. If we go farther and farther to the side, the individual portions of the antenna get more and more out of phase relative to one another and finally cancel each other out completely. In general, the more elements in the antenna, the narrower the beam and the stronger the signal in the forward direction. This means that if reasonable non-directivity is to be obtained, the antenna can only occupy about one square wavelength or less. One might think that all one needs to do in order to achieve a small station would be to increase the operating frequency until a wavelength is as small as is desired. This would be suitable if the station were only a transmitter, but if the antenna is also to be used for receiving, this cannot be done. The difficulty is that the amount of energy picked up by a receiving antenna is proportional to the area in square feet instead of the area in square wave lengths. Therefore, if the frequency is raised and the antenna is shortened, the amplitude of the received signal is lessened.

However, in fixed installations, where size is not a primary consideration, no such difficulty exists. If we maintain the same size antennas as the frequency is raised, the receiving antenna is just as effective as before, but the transmitting antenna is more efficient. At microwave frequencies it is possible to pick up almost all the radiated energy at the receiving end. In fact, for short distances, an antenna system can be more efficient than a coaxial cable.

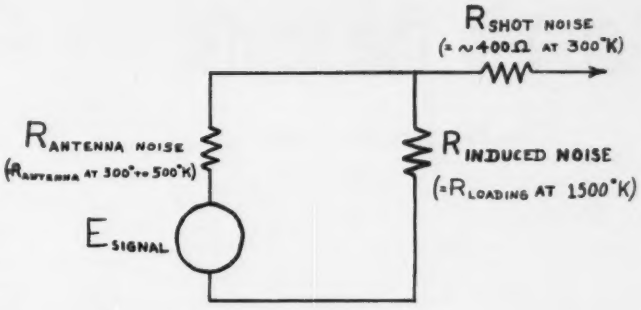
In the case of fixed antennas the only limit is the maximum frequency which can be generated and amplified efficiently. As one goes to higher and higher frequencies, the transit time of the electrons going across the vacuum tubes or transistors becomes more and more appreciable. When the frequency becomes so high that the electrons which start toward the control electrode (the grid in the case of the vacuum tube) during a positive swing do not get there until it has gone negative, the device will no longer work at all. This is a difficulty which is very hard to get around, because if the control electrode is moved closer to the cathode so that the transit time will be less, the input capacity is increased and the gain of the tube will fall off. The transit time lag produces a shift in phase of the current flowing past the control electrode relative to the voltage on the electrode. The phase lag can be represented by the presence of a resistor across the input capacity. Since the transit time is independent of the operating frequency, the phase shift in degrees is proportional to the frequency. The impedance of the input capacity is itself inversely proportional to the frequency, the resistor equivalent to the attenuation and phase shift of the signal must be inversely proportional to the square of the operating frequency. This resistance is called the grid loading resistance, and is of the order of a few thousand ohms in the one hundred megacycle region for most tubes.

Equivalent input circuit for signal.



By far the most important limitation on low power radio stations is the noise level with which the signal must compete. Noise can arise from many different sources. The most important of these are electromagnetic disturbances such as lightning, the Aurora Borealis, and sun spots, and man-made electrical devices. Man-made noise is especially im-

portant near cities. Corona from high voltage power lines, neon signs, automobile ignition systems, and other electrical gadgets are present in almost every locality. This noise occurs at all frequencies, but for high frequency operation, where signals and noise travel only as far as the line of sight, only the nearby noise sources are important. There are other sources of noise, however, from which there is no escape. These are the so-called thermal noises. They include noises introduced by the resistors and amplifying devices in the receiver, and the antenna noises which arise from fluctuations in the ionosphere and the atmosphere.



Equivalent circuit for noise level analysis.

In order to analyze a circuit from the point of view of noise it is necessary to get an equivalent circuit for a noise source. It turns out that the most convenient noise source is a resistor. Noise is generated in a resistor in the following way: electrons are accelerated by the electric field in the resistor until they collide with an atom. They impart some of their kinetic energy to the atom and start the process over again. The atom soon shares its kinetic energy with its neighbors, thus turning the kinetic energy of the electron into heat motion. From the point of view of the voltage across the resistor, these collisions represent an abrupt change in the current. It is true that this change is only a very small portion of the total current, but since the colliding is a random process, there will be times when many electrons collide, and times when few do. These fluctuations in the voltage across a resistor occur even when there is no voltage across it. The electrons in the resistor act somewhat like a gas, and even when there is no net flow, they are bouncing back and forth in a random way. The average value of the noise energy is proportional to the temperature of the resistor, since the temperature is a measure of the amount of random motion of the atoms and electrons in it.

When an analysis of the noise energy is made, it is found that in each frequency interval there is the same amount of noise energy. Thus if a resistor at temperature T is hooked up across a circuit with bandwidth B, the noise energy transmitted through the circuit is proportional to BT. From statistical mechanics it is found that the factor of proportionality is Boltzmann's constant. Since this constant K is so small ($K = 1.4 \times 10^{-16}$ ergs per degree) one is rarely concerned about this noise, but it does give a very useful way of analyzing circuits because any source of noise whatsoever can be replaced by a resistor at a certain temperature.

Noise generated by amplifying devices can be separated into two types. First, there is the so-called "shot" noise which is due to the individual electrons hitting the plate of a vacuum tube or the collector electrode of a transistor; and second, there is the noise induced on the control electrode by the electrons passing by. As the electron approaches the control electrode, it repels some of the electrons on the electrode, causing an increase in voltage. As the electron goes on past, these electrons return. Thus, each electron which passes the control electrode causes a small positive pulse to be superimposed on the signal. Shot noise can be likened to the difference between pouring oil through a funnel and pouring pebbles through it. If the electrons were continuous, the current would always be smooth, but since they are particles, they make a "noise" when they hit the electrode. This noise does not depend on the operating frequency.

An amplifier is also subject to induced noise, which is proportional to the frequency. The noise arises from the change in the capacity between the electron and the control electrode as the electron goes by. The high frequency components of the noise will see a smaller impedance and will therefore induce a larger voltage on the grid.

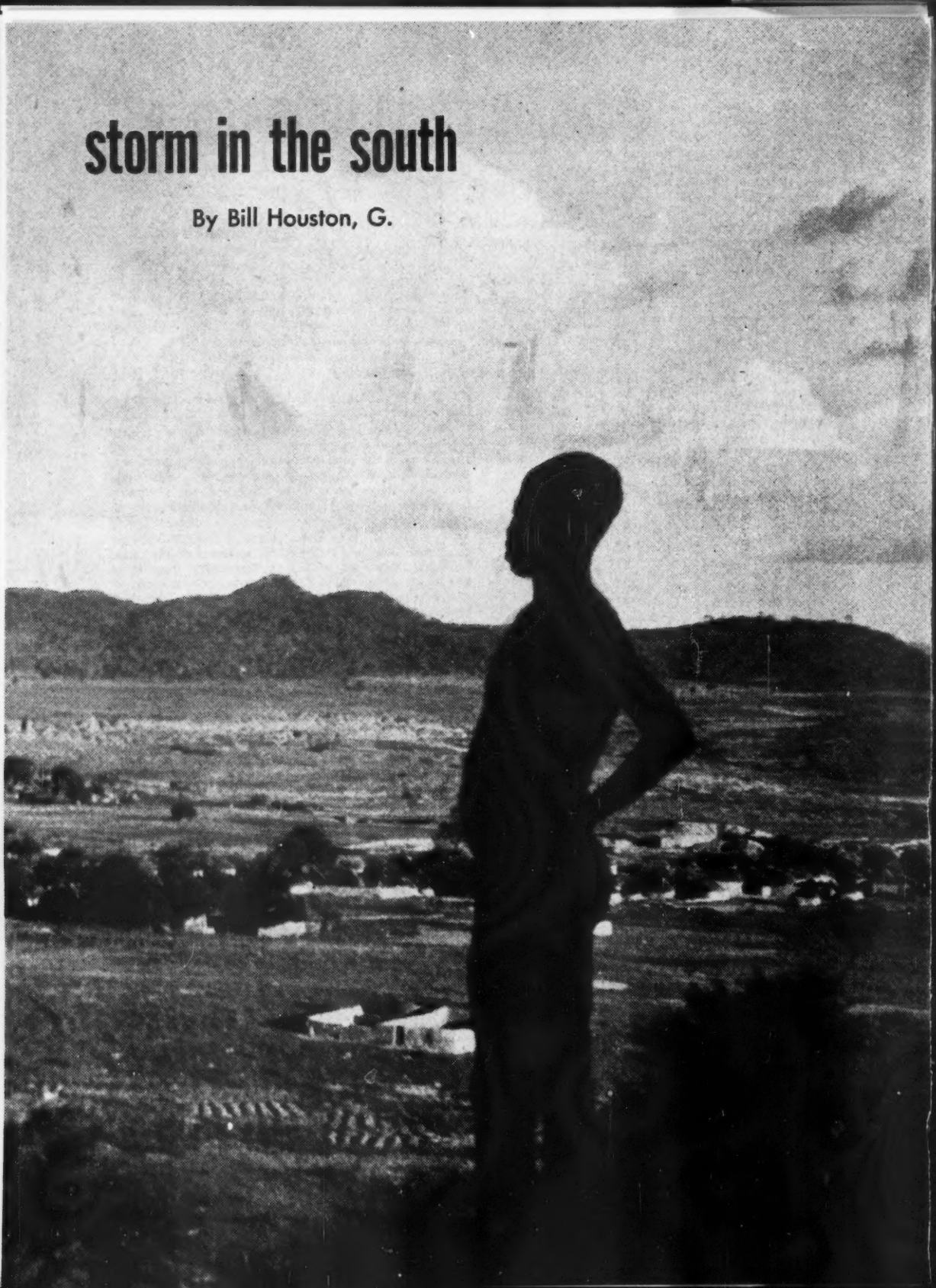
It is usually convenient, when analyzing a circuit from the point of view of noise, to lump all the noise sources together in one place. The logical place is at the input, since that is the place where the noise level can most easily be compared with the signal. One must therefore place in the input part of the circuit three resistors, one for antenna noise, one for shot noise, and one for the induced noise. It happens that there are already three resistors in the proper places representing the antenna impedance, the grid current impedance, and the grid loading resistance. It is possible, therefore, to keep the phase and attenuation relations for the input signal intact. In order to get the proper noise level analysis, one merely assigns each of these resistances a temperature appropriate to the amplitude of the noise coming from each of the sources. When this is done, it is found that man-made noises constitute the limit at the lower frequencies. At around one hundred megacycles, tube noises become greater. The best operating frequency from the point of view of noise depends largely on the range. For short range (up to about ten miles) the best frequency is above the point where signals are reflected from the ionosphere. This will eliminate all noise coming from sources farther away than the line of sight.

Even today commercial transmitters are operating with radiation powers of less than one watt. Notable in recent years are the microwave communication relay links. In the output circuits the link transmitters use klystron tubes. Since these tubes are primarily frequency modulated a further reduction of external noise is possible by proper receiver design.

In most receivers of today the noise power is of the order of 10^{-15} watts. If a transmitter is to radiate isotropically and produce a signal an order of magnitude larger than this in an antenna ten miles away which is about two feet long, only ten microwatts of power needs to be radiated. This is less than one per cent of the power needed to heat the filament of even the smallest vacuum tube. With the transistor there is no need for supplying all of this wasted power. Perhaps the realm of the wrist watch radio is not so far away.

storm in the south

By Bill Houston, G.



The southern portion of Africa is rich in gold and diamonds; it also has some uranium. The uranium is in the slag heaps at the gold mines, so no mining is required to extract it. The United States has recently granted the Union of South Africa a loan for further industrialization. In exchange, South Africa will sell her uranium to the United States, presumably to be used in the manufacture of nuclear weapons.

But in spite of the gold and the American dollars and the uranium and the diamonds, there is turmoil in South Africa. The non-white peoples are for the first time in the nation's history united in a non-violent civil disobedience movement aimed against various segregation and other laws which the non-Whites consider repressive.

Race relations have long been complex and unsettled in South Africa because of the many racial groups there and the differences in economic and political power of these groups. The largest of these racial groups is the native Africans, divided among various tribes but most of them speaking Bantu languages. Before Europeans began settling in Africa, these people had a primitive but stable civilization which included a powerful chief in each tribe, strong family ties in which children obeyed their parents, and ancestor worship. The African economy was based mainly on the raising of cattle with little agriculture. There are about eight million native Africans in the total population of about twelve million.

The next largest section of the population is the White or European group, which numbers about two and a half million. Of these over one and a half million are descended from Dutch settlers who began colonizing South Africa in 1652. Their language has gradually changed from pure Dutch to a dialect called Afrikaans, and, as they feel no particular loyalty to the Netherlands or to Britain, they call themselves Afrikaners. Their economy was originally agricultural and pastoral with large farms and ranches of about seven thousand acres each. Most of the Afrikaners still live on farms, though many now work in the mines and factories; because of the increase in population, the size of a farm is more likely to be a couple of thousand acres. The rest of the European population is of British descent. The majority of white factory and mine workers and of the white urban population generally is British. Almost all of the bourgeoisie are in the British group, and there are a few British farmers.

There are nearly a million South Africans, mostly in the Cape Province, of mixed ancestry — part European and part African. These people are called "coloreds" and enjoy certain rights (e.g., the franchise) denied to the native Africans.

About 1865 Indians began to be imported into South Africa as indentured servants to work on the sugar plantations in Natal. Other Indians entered South Africa as small merchants, primarily to sell to their fellow Indians. They also built up a large trade among the Negroes and some among the Whites. The Indians now number about a quarter of a million, most of whom are small shop-keepers.

One of the main differences between the problems of South Africa and those of northern Africa and colonial Asia is that in the latter areas there is a very small and temporary white population, with actual rule coming from Europe, while ever since the Whites came to South Africa three hundred years ago, they have settled and set up their own government. These first Dutch settlers built farms and ranches and waged fierce war against any Negroes who tried to interfere. After defeating the Negroes, they employed them on their farms. Slavery was established. As a result of the master-slave relationship, the Dutch, or Afrikaners, developed strong beliefs in their racial superiority over the Negroes and even incorporated this belief into the doctrine of their church. To this day one of their chief slogans is "No equality in Church or State."

As the Netherlands began to wane and Britain to rise as a colonial power, the British took over political control of the Cape of Good Hope and started talking about things like educating the natives and eventually giving them equality. These notions shocked the Afrikaners, and when (in 1836) the British began acting on them by abolishing slavery, the Afrikaners trekked north and founded independent republics. The Boer War at the end of the nineteenth century resulted in the defeat of the Afrikaners and British control over the new republics. However, Britain granted South Africa dominion status with self-government in which all Whites (both Afrikaner and British) had the vote. Originally certain Negroes and Indians had the franchise also, but this has since been changed. The "coloreds" (i.e., those of mixed ancestry) in the Cape of Good Hope are still allowed to vote.

Because of enmities arising from the Boer War, relations between the British and Afrikaners are still not good. As mentioned above, the British are mostly urban while the Afrikaners are rural. Hence the usual distrust of the "city-slicker" by the farmer and the contempt of the city dweller for the yokel adds to the tension between British and Dutch. While both groups now fully believe in the doctrine of white supremacy, they differ as to how best to ensure it — the Afrikaners favoring a policy of complete *apartheid*, meaning that eventually Europeans and Negroes will have *no* contact — not even in a master-servant relationship — and the British favoring limited segregation in which both Whites and Negroes participate in the same economy but with Negroes performing the menial jobs and getting less pay. Prior to 1948 the government was controlled by the United Party which holds the British view. During that time laws were passed restricting the right of Negroes to hold property and to join labor unions. Since 1948 the government has been under the Afrikaners, and the Jim Crow laws have been tightened somewhat. However, the government has not been able to put into effect the complete *Apartheid* which it advocates because the industry and agriculture of the Whites are so dependent on cheap Negro labor that to remove it (as called for under *apartheid*) from the white economy would probably cause that economy to collapse. Meanwhile the Negroes and Indians are suffering under partial *apartheid*. There are certain areas where only Africans are allowed to live, other areas for Indians only, and still others for Europeans only.

About forty per cent of the Negroes still live in rural areas which they themselves own. Although some attempt has been made to preserve the stability and security of life under the old tribal system, the overcrowding of the land, together with the new ideas of natives who have been to the cities or the mines and come back home, have pretty well destroyed the authority of the chief and of the home. The rural areas in which natives live are called native reserves and comprise about one-eighth of the total area of South Africa (but probably somewhat more than one-eighth of the total arable area). The native reserves are the only place in the Union where native Africans may own land.

Within the reserves there is not so much farming as

Picture from *African World*

The Torch Commando, a war veterans organization led by Group Captain A. G. ("Sailor") Malan, the famous Battle of Britain fighter pilot, has become a vital political force in South Africa. Captain Malan is not to be confused with Dr. Malan of the Nationalist party. This picture shows "Sailor" Malan being carried shoulder-high when the "Steel Commando" of jeeps arrived at Cape Town to stage a protest against the Nationalist Government's recent legislation.

there is cattle-raising. There are more cattle than the land can support, and overgrazing has caused much erosion. To combat this, the government has passed laws empowering local administrators to kill some of the cattle belonging to natives whose herd is deemed too large. Though the government says these provisions are necessary to preserve the land, most Africans dislike having their cattle killed.

About thirty per cent of the Negroes serve as laborers on farms owned by Europeans. This type of work is strictly controlled by laws which require the laborer to work for the farmer one hundred eighty days a year, for which he and his family receive a place to live, something to eat, and about two dollars a month. If his wife and children also work, each of them gets about a dollar and a half a month. Sometimes the laborer is also given a couple of acres of his master's farm for himself.

Also, some African men work in the mines. They are housed in large barracks belonging to the mine owners; if the miner is married, he must leave his wife at home on the native reserve during his term of employment. Besides food and housing, the miner is paid about eight dollars a month.

The other thirty per cent live in or near the cities. Near each city is a "native location" in which native Africans live but are not allowed to own land. The natives are forbidden by law to live in any other part of the city, except in the case of domestic servants who may live on the premises of their employers. Negroes in urban centers live under all kinds of restrictions known as Pass Laws. These laws require a Negro woman living in a native reserve to secure a pass if she wants to join her husband who is working in the city; a man must have a permit to look for a job and a badge if he has found a job; a pass is required anytime a native leaves the location unless he is going to work; there is a curfew for Negroes, and if a Negro wants to be out after the curfew he needs a pass. The laws applying to South African Indians are similar but not nearly so severe.

The first organized resistance by non-Whites to the discrimanatory laws against them was undertaken by the Indian Community under the leadership of a then unknown lawyer named M. K. Gandhi. The movement was directed against three laws — one similar to the pass law described above, one imposing a heavy tax on Indians but not on Whites, and one invalidating Hindu and Moslem marriages and thus depriving Indian children of their inheritance rights. The technique used in resisting the laws was called *satyagraha* by Gandhi and later proved to be effective in gaining India's independence. As *satyagraha* worked in this case, the people refused to register for the passes, a group of Indian women without the required permit picketed a mine where Indian men were working, and the men then went on strike, also without a permit. For all these violations of law many Indians were imprisoned and beaten, but no violence or trickery was used by the Indians. Finally in 1913 the government repealed the objectionable laws. For a full discussion of this campaign, see M. K. Gandhi, *Satyagraha in South Africa*, Navajivan Press, Ahmedabad 9, India, 1950.

Picture from *African World*

The arrest of Mr. E. S. Sachs, a prominent South African trade union leader, when he addressed a mass meeting of the Garment Workers' Union on the steps of the Johannesburg City Hall, led to rioting in which many people were injured. Mr. Sachs was arrested in connection with the Suppression of Communism Act. Above, garment workers assembled outside the City Hall scatter as club-swinging police charge the crowd. Below, previous to the police charge placards carried by the crowd warn against the arrest of Sachs.

Shortly after World War II, when oppressed peoples all over the world began demanding freedom, the leaders of the African National Congress (A South African political action group composed of natives) decided to apply the non-violent methods developed by Gandhi. The African National Congress realized that in order to maintain the non-violent character of the movement, much self-control would be required of the participants. Accordingly Congress began training its members in the philosophy and discipline of *satyagraha*.

Although in the past there has been hatred between the Negroes and Indians, the Negroes sought and obtained the co-operation of the South African Indian Congress and the Franchise Action Council (a "colored" group). Leadership remained under the African National Congress.

On December 17, 1951, Congress decided the people were ready to begin the campaign. Dr. Malan, South Africa's prime minister, was informed that if the government had not indicated its willingness to repeal certain legislation by March 1, 1952, a civil disobedience campaign would be begun at some time thereafter. The laws involved were:

1. The Group Areas Act: This is the law forbidding non-Europeans to hold land in most of Africa.
2. The stock limitation provisions described above.
3. The Pass Laws described above.

Horace Greeley's advice is still good . . .

"Go West, young man... go West"...

to Marquardt Aircraft Company, located in California's fabulous San Fernando Valley, where you will find your engineering future unlimited with the organization that is first and foremost in ramjet research, development, testing and production.

Marquardt also designs and manufactures afterburners – pulse jet engines – auxiliary power units – automatic engine controls.

marquardt

Write today for full information concerning your future with Marquardt to Industrial Relations Dept., Marquardt Aircraft Company, Van Nuys, California.

Do you know any of these M.I.T. Alumni now at Marquardt?

NAME	DEGREE	YEAR
LAWRENCE CAMPBELL	ScD CE	1951
ROBERT SAKS	BS AE	1939
PHILIP VALENTINE	MS ME	1949
RONALD Y. YOSHIDA	BS ME	1952

4. The Bantu Authorities Act: This law sets up a hierarchy of rulers in the native reserves.

5. The Suppression of Communism Act: This gives the police arbitrary powers to arrest anyone the Minister of Justice says is a Communist.

6. The Separate Registration of Voters Act: This bill attempted to disfranchise the "colored" voters in the Cape Province.

Before the campaign began the three sponsoring groups stated:

"All people, irrespective of the national groups they may belong to, and irrespective of the color of their skin, who have made South Africa their home . . . are South Africans. . . . The struggle which the national organizations of the non-European people are conducting is not directed against any race or national group. It is against the unjust laws which keep in perpetual subjection and misery vast sections of the population. It is for the transformation of conditions which will restore human dignity, equality, and freedom to every South African."

In a later statement the leaders of the African National Congress said, "We desire to state emphatically that it is our desire to conduct this campaign in a peaceful manner, and that any disturbances, if they should occur, will not be of our making."

The civil disobedience campaign began on June 26, 1952. A typical incident in the campaign occurred that afternoon in Boksburg, a native location near Johannesburg. That morning the Congress gave a letter to the police telling them, "We advise you that . . . the persons named in the attached list will defy the permit regulations and deliberately court imprisonment by entering Boksburg location at 2:30 without the necessary permits." The group arrived at Boksburg on schedule. The police were waiting and arrested them. The Africans offered no resistance, but went off to jail singing a hymn. Similar events have been occurring all over South Africa. Sometimes Negroes will use the "European" entrance to a railroad station. Sometimes Indians enter an area reserved for Negroes. Sometimes a white man enters the Negro section of a post office. In every case a law is violated and the violator is jailed.

The leaders of the African National Congress and the South African Indian Congress were served with orders forbidding them to attend any public meetings. This can be done under the Suppression of Communism Act. The leaders refused to obey and were arrested. At the trial of one of them the magistrate said, "It is common knowledge that one of the aims of Communism is to break down race barriers and strive for equal rights for all sections of the people, and to do so without any discrimination of race, color, or creed. . . . This would endanger the survival of Europeans, and therefore legislation must be passed with the object of suppressing Communism."

When the movement began, most white "liberals" and some non-whites feared it would burst into violence. Thus far over eight thousand people have gone to jail as a part of the campaign, and there has been no violence on the part of the resisters. There have been three riots in South Africa since the campaign began, but these had no direct connection with the civil disobedience movement. Many of those who were at first sceptical have since joined in. For example, Alan Paton, author of *Cry the Beloved Country*, joined in a statement deploring the movement when it first began. He is now directing the distribution of aid to the families of those who have gone to jail. Manilal Gandhi, son of the Mohatma, advised the African National Congress not to undertake the campaign. But after three months of it he wrote, "I am simply amazed at the non-violent spirit and the discipline the Africans in the present campaign are showing. No one had dreamt they could keep so calm, cool, and collected. Father's spirit seems to be watching over them." Manilal Gandhi has himself since been arrested for violating the *apartheid* laws.

The South African government has shown signs that it is beginning to worry. A so-called whipping-post law has been passed making it legal to lash prisoners arrested as a part of the disobedience movement. Another recent law makes it a crime to give any sort of aid to a participant in the resistance movement and allows the government to seize any money sent to or for such a participant.

The philosophy and logic on which *satyagraha* is based are simple. The object is usually to remove some sort of oppression of one group by another. However rather than assume that the only way to change the oppressing party is to force him to change, *Satyagraha* assumes that violence is bad and that bad means can never really accomplish a good end. And *satyagraha* also holds that love can accomplish much, and that if one always acts in love the result will be good.

The object of the non-violent civil disobedience movement then is to give the government an emphatic demonstration of the Africans' belief that they are being unjustly treated, and to appeal to the Europeans to act with justice. *Satyagraha* seems to be the only method of resisting oppression which proceeds from a concern for both the oppressed and the oppressor and considers the welfare of both.

A NEW RELAY RECORD

RELAYS—which are high-speed switches—are the nerve centers of the dial telephone system. In a split second, they set up a connection and then are off to direct the next call. In a large city, more than 1000 relays are used every time a number is dialed.

Now a new wire spring relay—devised by the Bell Laboratories—is at work. With only 11 instead of 70 parts, it is twice as fast, uses less power, and costs less to make and maintain than its predecessor. Result: calls go through faster and switching is done with less equipment.

Men and women of the Bell System—in operating, manufacturing and laboratory work—continually seek new ways to improve telephone service. Qualified engineering graduates can find well-paid and interesting careers in the telephone business. Your placement officer can give you details about opportunities for employment in the Bell System.

BELL TELEPHONE SYSTEM

tech engineering news

Professional Journal of the Undergraduates of the
Massachusetts Institute of Technology

Managing Board

D. F. Shrader, '58 . . . . . General Manager
D. F. Shrader, '58 . . . . . Editor-in-Chief
D. F. Shrader, '58 . . . . . Managing Editor
D. F. Shrader, '58 . . . . . Business Manager

Junior Board

D. F. Shrader, '58 . . . . . Literary Associate
D. F. Shrader, '58 . . . . . Literary Associate
D. F. Shrader, '58 . . . . . Advertising Manager
D. F. Shrader, '58 . . . . . Circulation Manager
D. F. Shrader, '58 . . . . . Art Editor
D. F. Shrader, '58 . . . . . Make-Up Editor
D. F. Shrader, '58 . . . . . Co-Sales Manager
D. F. Shrader, '58 . . . . . Co-Sales Manager
D. F. Shrader, '58 . . . . . Office Manager
D. F. Shrader, '58 . . . . . Technical Consultant

Staff

Arnold Levine, '53
Kenneth Klopf, '56
Dave Klepper, '53
Raymond Archambault, '56
Jon Jansen, '56
John Byrnes, '55
Garry Quinn, '56
Gary Kincaid, '56
George Raymond, '55
Andrew Viterbi, '56
Mike Ginsberg, '56
David Sternlight,'56
Knute Nomland, '55
Howard Simmons, '54
John Rossettos, '55
Leonard Ruthazer, '56
Jerry Tiemann, '53

Staff Candidates

Norman R. Gardner, '53
Herbert Jacobson, '54
Will Thomson II, '53
Marilyn Leader, '54
Paul Spreiregen, '54
Don Eckhardt, '55
John R. Shrieffer, '53
Peter Embree, '55
Dan Brzezenski, '53
Tom Cantrell, '55

Candidates for Staff Candidate

Anthony Ranti, '53
John Mathis, '53
Sherwin Tlak, '53
Raymond D'Arcy, '54

Left Out

Henry Snider, '55

Publisher's Representative

Littell Murray Barnhill, Inc.
101 Park Avenue, New York
605 North Michigan Avenue, Chicago

from the editor's notebook

"Tyranny," cried the students; "Public opinion," replied the Administration.

The status of the student on the MIT campus is undergoing considerable change. A number of voices have been raised to protest against the transition, but they have been ineffective. On the one hand, we have our Administration advocating an adherence to "accepted" standards, public opinion, and the premise of handling student life for the general welfare of corporation, administration, faculty, and student. To balance this "mature" attitude, the student puts forth his brashness, youth, idealism, and spontaneous individuality. An unusual, and highly discouraging, aspect of the present controversy is the apparent inability of the Dean's Office to understand or meet the question on anything other than a set of erroneous, highly "practical" considerations. In fact, the present student reaction is received as further evidence of the need for increased control. Herein lies the frustration of seeing an ideal swallowed by ill-based expediency.

It is not too surprising that the outcome of this unfortunate situation is becoming daily more clear. The student has technically elected representatives, who are cognizant of student problems and points of view. In addition, they should be articulate people — willing and able to present views effectively and forcibly. Past experience and present circumstance would indicate that this is not the case. Instead, due partly to the lack of an original approach, our representatives are placed in the position of merely reviewing already formulated proposals. It is obvious that the changes they are permitted to make, if any, are minor and in no way affect the general trend. How then is this situation to be handled? One might propose a stronger student government, an increased representation by students on matters that so directly affect them. In the present situation, which I hope may be only temporary, this is clearly not possible. Instead, I propose that student government assume a different and more logical position, for the present. In short, a complete withdrawal from the political and policy-making scene is in order. The presence of the student, through his representative, conveys the erroneous impression that he is an integral part of the proceedings and, in part, responsible for the policies evolved. The student government should maintain itself as a service organization, with such functions as arranging dances. Under these conditions, the source of policies and "memoranda" would be clear. There would be no ambiguity. The benefits to be gained through such action would far outweigh the loss of "official" representation, which is not much short of a farce under present conditions.

To retract representation and not replace it with another means of expression would appear unwise. What then is the replacement? As Dean Bowditch so boldly points out: "Public opinion is a strong factor . . . and may prevail over honest conviction." If conviction might be bolstered by an appeal to public opinion a very interesting channel of influence is made available. Open meetings between student and Dean might serve to clarify and bring into focus issues involved; letters to parents, alumni, members of the Corporation, Institute officials, and the Dean would make clear the depth of the issue and the real nature of public opinion in the situation with which we are now concerned; the full utilization of means of publication should also be of value.

While it is regrettable that the events motivating this editorial should come to pass, it is equally unfortunate that those for whom it is intended, will profit least from it. It is a sad fact that wisdom is not always a companion of power. A continuance of the present trend (if only a trend it be) toward the total disregard of student rights and opinions would force me to urge a change in student outlook and action — from civilized discussion to civil disobedience.

N. R. G.

Whenever fastening problems arise...

Consider ELASTIC STOP NUTS

LOOK FOR THE RED LOCKING COLLAR

It is threadless and resilient. Every bolt impresses (but does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads—and eliminates axial play between bolt and nut threads. All Elastic Stop Nuts—regardless of type or size—lock in position anywhere on a bolt or stud, maintain accurate adjustments and seal against liquid seepage. Vibration, impact or stress reversal does not disturb prestressed or positioned settings.

Whenever fastening presents a problem—ESNA is ready with a quick answer. More than 3000 types and sizes of self-locking vibration-proof fasteners—plus the "know-how" of ESNA engineers—are available here at ESNA.

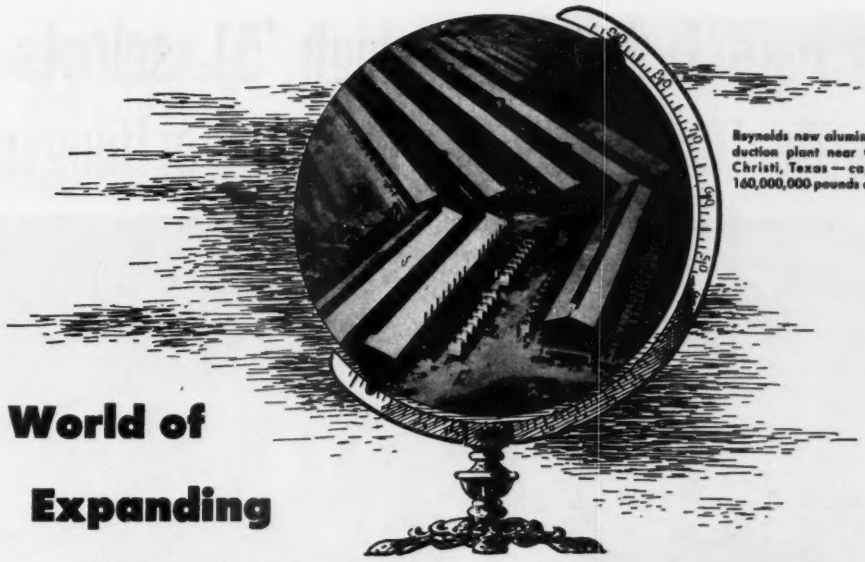
ESNA has long been known as "design headquarters" for self-locking fasteners. Accepted by Army, Navy and Air Force, virtually every aircraft built in the past decade has been Elastic Stop Nut-equipped. On the railroads, in the oil fields, on automobiles and construction equipment, Elastic Stop Nuts manufactured to exacting quality control standards, are doing specialized jobs every day.

Be familiar with the design help ESNA offers. Write us for details on Elastic Stop Nuts. Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, N. J.

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA

DESIGN HEADQUARTERS FOR SELF-LOCKING FASTENERS



Reynolds new aluminum reduction plant near Corpus Christi, Texas — capacity 160,000,000 pounds a year.

A World of Expanding Opportunity!

In a land noted for rapid expansion of free industrial enterprise, few companies have matched the swift and continuing growth of the Reynolds Metals Company. Now operating 27 plants in 13 states, and still expanding, Reynolds offers the ambitious engineering graduate a world of opportunity.

Reynolds operations include bauxite mining in domestic and foreign locations...chemical and electrolytic processing to produce aluminum pig ...sheet rolling...drawing and extrusion of mill and structural shapes ...foil rolling and printing...powder and paste production...finished parts and products fabrication. In these and in the allied sales and marketing operations promising careers exist for graduates in virtually any phase of engineering.

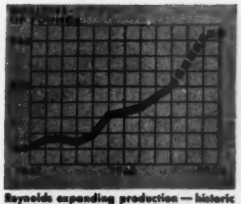
On-the-job training is the Reynolds policy—after preliminary orientation which may include basic experience in production plants for sales personnel, and sales office work for technical trainees. Liberal insurance, hospitalization and retirement programs are maintained.

For important background information on "your future in Aluminum," *mail the coupon.* If you are definitely interested now, write direct to General Employment Manager, Reynolds Metals Company, 3rd and Grace Streets, Richmond 19, Va.

Tapping one of huge battery of electrolytic cells

Sheet rolling—reverse hot mill in operation

REYNOLDS ALUMINUM



Reynolds expanding production — historic chapter in 33 years of continuing growth.

Reynolds Metals Company, Employment Dept.
Richmond 19, Virginia

Please send me, **FREE**, your 96-page booklet, "The ABC's of Aluminum"; also the 44-page book, "Reynolds Aluminum . . . and the Company that makes it."

Name_____

Address_____

Richard J. Conway, Lehigh '51, selects Manufacturing Engineering at Worthington

RICHARD CONWAY checks cutting tool with machinist before milling a pump casing.

After completing his general training which brought him in contact with all departments, Richard J. Conway decided that manufacturing engineering was his field. He says, "I chose the Manufacturing Engineering Department after completing my general training at Worthington because as a graduate in Industrial Engineering I can learn the practical aspects of my field while applying theory I learned in college.

"The personnel of this department work together as a team toward the solution of the numerous problems which arise daily. We have the cooperation of all other departments in the corporation in getting the necessary facts pertinent to the solution of these problems. In the course of our day it may be necessary for us to meet the Plant Manager, Chief Engineer, Comptroller, several department heads, clerks, foremen, machinists and many others throughout the company.

"I have contributed to the solution of many problems handled by this department including metal spraying, machining procedures, purchasing new equipment and designating proper dimensions to obtain desired fits between mating parts.

"I enjoy my work because I'm doing the work I want and my formal education is being supplemented with practical knowledge gained from the tremendous wealth of knowledge available to me at Worthington. I know from personal contact with many other departments in the Corporation that Worthington can and will find their young engineers a spot which will give them the same opportunities as have been afforded me."

When you're thinking of a good job, think *high*—think *Worthington*.

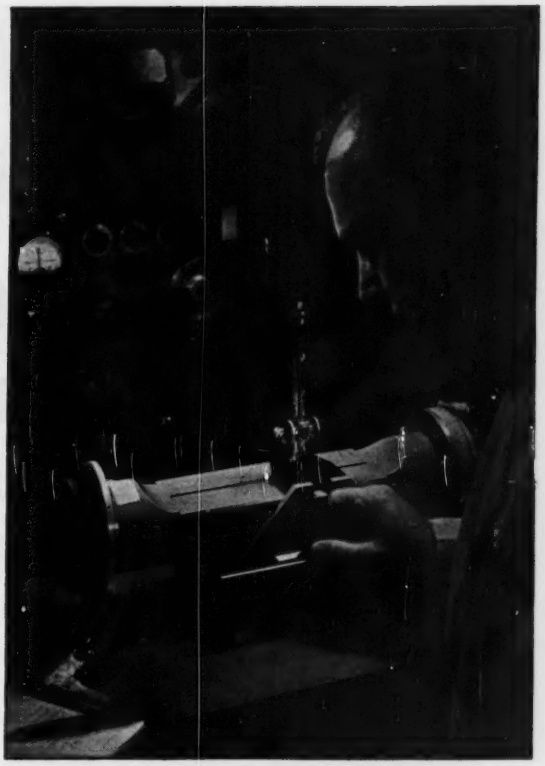
FOR ADDITIONAL INFORMATION, see your College Placement Bureau or write to the Personnel and Training Department, Worthington Corporation, Harrison, N. J.

WORTHINGTON

The Sign of Value Around the World

Build your future with Bendix

AVIATION CORPORATION



JOIN AMERICA'S LEADING TEAM OF CREATIVE ENGINEERS!

Your opportunity is as big as you want to make it in Mechanical Engineering • Hydraulic Mechanisms • Electronics • Magnetics • Computers • Servo-mechanisms • Radar Research • Metallurgy • Solid-State Physics • Instrumentation • Radiation Detection • Nuclear Physics • Guidance and Control Systems plus many more engineering fields.

You'll find Bendix has much to offer the young graduate engineer of today. It's only natural since the Bendix Aviation Corporation is primarily a *creative engineering* and manufacturing organization—unlike any other in America in its versatility, facilities, experience and range of products. And of real importance to you is the fact that this firm is engineering-minded from top management down. Currently, Bendix engineers—an average of 1 out of 18 employees as compared to the all-industry average of 1 out of 50 employees—are building important careers for themselves in design, development, research, production supervision and sales. Many of these men come from schools such as yours. Whatever engineering field you've trained for, and wherever your interests lie in that field, you'll find positions at Bendix that provide the answer you've been looking for. Plan now to build your future with Bendix!

BENDIX AVIATION CORPORATION
Executive Offices: Fisher Building, Detroit 2, Michigan
DIVISIONS, PRINCIPAL SUBSIDIARIES AND AFFILIATED COMPANIES

Bendix Products Division, South Bend, Indiana
Hamilton Division, Hamilton, Ohio
Bendix Radio Division, Towson, Maryland
Eclipse-Pioneer Division, Teterboro, New Jersey
Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio
Utica Division, Utica, New York
Bendix Computer Division, Hawthorne, California
Eclipse Machine Division, Elmira, New York
Friez Instrument Division, Towson, Maryland
Marshall-Eclipse Division, Troy, New York
Pacific Division, North Hollywood, California
Red Bank Division, Red Bank, New Jersey
Skinner Purifiers Division, Detroit, Michigan
Cincinnati Division, Cincinnati, Ohio
Scintilla Magneto Division, Sidney, New York
Zenith Carburetor Division, Detroit, Michigan
Kansas City Division, Kansas City, Missouri
York Division, York, Pennsylvania
Bendix Aviation Research Laboratories, Detroit, Michigan
Pioneer-Central Division, Davenport, Iowa

Nation-wide Network of Plants and Laboratories Enables You to Choose Your Location

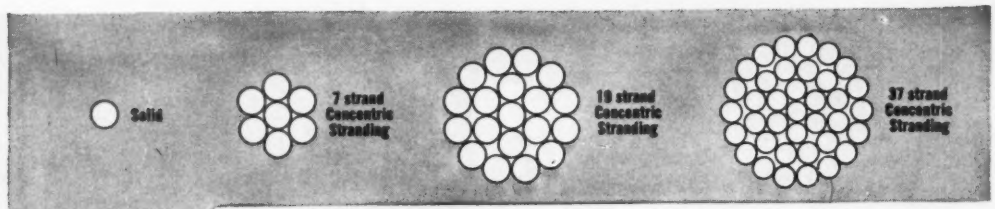
Bendix operations and activities are distributed among 13 laboratories and 22 manufacturing centers. Each functions independently with its own engineering staff. As a result, you enjoy a small company atmosphere but benefit from the facilities of a large organization. Last year, Bendix spent over $50,000,000 for engineering alone. For sure, ideas are not cramped at Bendix!

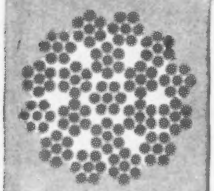
For complete information on a Bendix engineering career, have your placement office arrange an interview for you with the Bendix Representative who will be at your campus soon. Or write to:

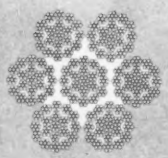
Bendix
AVIATION CORPORATION
FISHER BUILDING
DETROIT 2, MICHIGAN

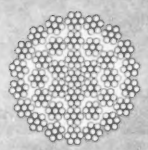
Bendix Products Are Used in These Industries and Services

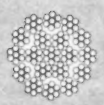
Agriculture, Automotive, Aviation, Electronics, Atomic Energy, Lumber, Marine, Metals, Petroleum, Construction, Public Service, Railroad, Textile











No. 2 in a series

The Importance of Electrical Conductors

In the ability to transmit electricity, all forms of matter may be divided into two general classes, namely, conductors and insulators. Conductors permit electric current to flow readily; that is, they offer little resistance to its flow, whereas, insulators offer relatively great resistance to the flow of electricity. All substances at normal temperatures offer some resistance to the flow of electric current. In general, the metals are good conductors, while glass, oil and most organic substances are classed as insulators. Although silver offers the lowest resistance to the flow of electricity of the common metals, its cost is such that it is not widely used as a conductor. The conductors most generally used in the cable industry are made of copper or aluminum.

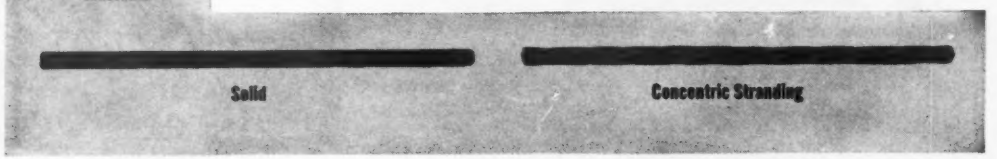
The manner in which electricity flows through elementary material may be readily visualized from the modern concepts of the structure of matter. According to these concepts all elements are made up of minute indivisible particles called atoms. These in turn are composed of a positively charged nucleus around which one or more very small negatively charged particles, called electrons, rotate at high velocity. In conductors, some of these electrons are free to move when only a small difference of potential is applied to the ends of the conductor and, since they are negatively charged, they flow to the positively charged end. This movement of electrons is electric current.

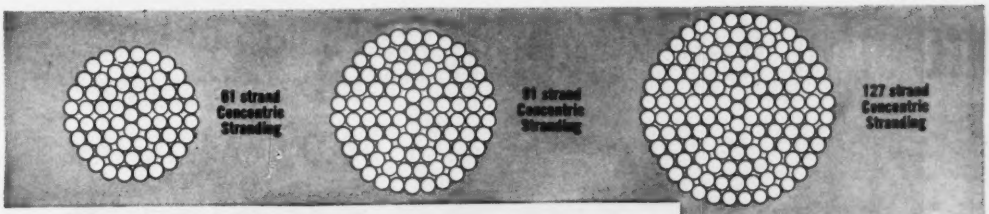
In passing through conductors, *the electrons must pass through the electron fields of many atoms. They thus collide with the atomic nuclei and other electrons. These collisions obstruct the flow of electrons and result in electrical resistance.*

The resistance of a homogeneous conductor of uniform cross-sectional area varies directly as its length and inversely as its cross-section, the length being in the direction of current flow. That is, $R = \rho L/A$ where, R is the resistance in ohms, L is the length in the direction of current flow, A is the area perpendicular to the length and ρ is a constant of the particular material known as its specific resistivity. When the length and area are expressed in the same units such as L = one inch and A = one square inch, $R = \rho \times 1/1$ or $R = \rho$, the specific resistance of the material in ohms per inch cube.

The length and area of a conductor are generally expressed in other units than inches. The most commonly used unit of cross-sectional area used in the cable industry is the circular mil, usually designated as cir. mil or CM. This

UNITED STATES RUBBER COMPANY





is the area of a circle whose diameter is one mil, 0.001 inch. The area of a circular mil is $\pi/4$ or 0.7854 of a square mil. The unit of length usually associated with this unit is the foot and the resistance becomes ohms per CM-foot. The resistance of annealed copper and aluminum per circular mil-foot at 20C are 10.371 and 17.011 ohms respectively. The resistance of a copper conductor 64 mils in diameter and one foot long thus becomes $10.371 \div 64^2$ or 0.00253 ohms.

The sizes of electrical conductors *are expressed in the United States in terms of the American Wire Gauge. This was originally set up on the basis of a geometrical progression of 39 steps or sizes between a wire 460 mils in diameter (Size 4/0) and a wire 5 mils in diameter (Size 36). The ratio of the diameter of a wire to that of the next larger size in this series is 39 $\sqrt{460/5}$=1.12293. This ratio has since been used to extend the American Wire Gauge (AWG) to sizes smaller than 36 AWG (5 mils). The sizes of conductors larger than 4/0 are expressed in circular mil area. The size of a conductor made up of a number of wires is determined from the sum of the circular mil areas of the individual wires.*

When current flows through a conductor there is, according to Ohm's law, a voltage drop of E = IR, where E is in volts, I is in amperes and R is in ohms along the conductor and power equal to EI watts is converted to heat. Since E=IR, this power converted to heat becomes I^2R watts. These two factors, voltage drop and conductor heating, are of prime importance in the design of conductors. Conductors must be sufficiently large in cross-sectional area, that is, must have sufficient low resistance that the voltage drop does not become excessive. In good design this voltage drop should not exceed 3 per cent for power circuits or 1 per cent for lighting circuits. The conductors should also be large enough that their temperature does not exceed that for which their insulation is designed. This is referred to as the current carrying capacity of conductors. The current carrying capacities of the various sizes of conductors, conductor insulations and installation conditions have been established. It should be noted that the temperature attained by a conductor depends not only on the amount of heat generated but also on the thermal resistance of its surroundings.

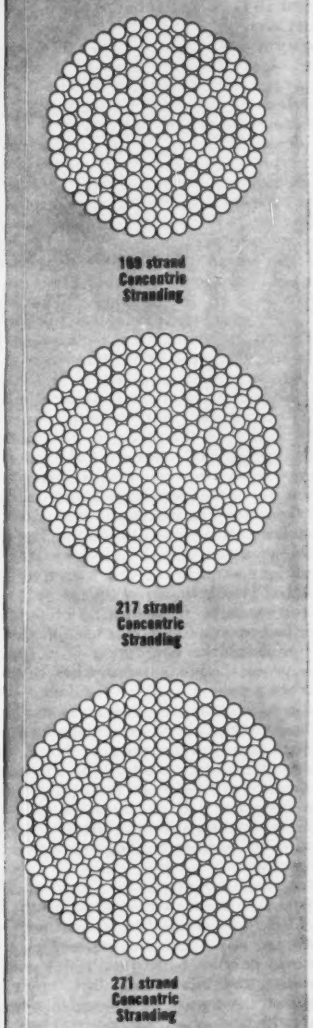
In addition to providing satisfactory voltage drop and current carrying capacity, conductors must be designed to provide adequate flexibility during installation and service. This is accomplished by building up the conductor from one or more adequately small wires depending on the flexibility required. For example, the conductor for heater cord or welding cable which is subject to repeated flexing in service is usually made up of copper strands having a diameter of .005" or .0063" while the conductor for overhead weatherproof cable may be a single wire.

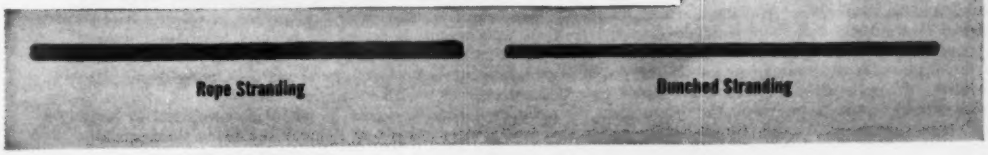
For reprints of these pages write to address below.

U.S.RUBBER
SERVING THROUGH SCIENCE

Electrical Wire and Cable Department

Rockefeller Center • New York 20, N. Y.





control in digital computers

By David Sternlight, '54

In the second of this series of three articles, I described arithmetical processes in digital computers. Now we shall see how a computer "knows" what to do, and what is equally important, when to do it. Circuits that perform timing and selection functions are known as "control circuits." The heart of the computer is the "master clock," a device which produces regular pulses which control the operation of the computer. The instructions on computer functioning are wired into a device called the "operation control matrix."

The input and output equipment of modern computers is most interesting. Data is usually punched on paper tape and read into the computer at high speed from the tape. Here at M. I. T. facilities are available for reading the tape punched by Flexowriter office typewriters, with a special taped "conversion routine," which is fed in before a Flexo-coded tape and "explains" the Flexo code to the machine. This simplifies the problem of getting information into the computer, since one can merely type out the program on a Flexowriter, using agreed upon abbreviations which the computer can understand, such as *ca* for clear the accumulator and add the contents of the register number following the "ca" command. For example, "mr 443" would multiply what is in the accumulator "mr" by the contents of register 443. Some of the other commands that many computers can execute are to divide, subtract, transfer digits from one place to another, transfer control from one section of the computer to another, and transfer control conditionally. By transfer conditionally we mean that if a given number is positive, there will be no transfer; if it is negative, there will be a transfer. This last instruction is very useful, since it enables a computer to perform functions of judgement. An excellent example of the use of this judgement instruction is in the evaluation of a function by an iterative process. The computer has to be able to tell when it has taken enough evaluations. The way this is done is to subtract a constant from the number of times the operations have been performed and give this conditional transfer command. When n operations have been performed, where n is the constant mentioned above, the conditional instruction will be ignored and the computer will go on to the next step. Until then, the instruction will take effect, and the computer can be directed back to the beginning of the evaluation by this method.

Instructions are stored in the form of "ca nnn," where "nnn" is the register containing the information to be added. An instruction known as "ao" will add one to this or any other instruction.

It is also possible to feed data into most computers by operating toggle switches, but this is undesirable except for testing purposes, since it ties up valuable computer time.

In addition to conversion routines, other useful techniques called subroutines have been developed by various computer staffs for use on their machines. These are complete operations and processes, prepared for generality of application. These subroutines can be spliced directly into a program to accomplish a frequently used operation. There are also tapes called postmortems which can be fed into a computer when a program goes awry. These will let the computer indicate to the operator what is wrong.

A great deal of ingenuity is being displayed by the designers of computer output equipment. For example, at M. I. T. the Whirlwind computer can perform all of the following operations automatically, upon receiving the proper instruction:

Print out on a typewriter.
Punch data on a paper tape.
Display information, both numbers and curves, on a scope.
Photograph scope displays.
Record large quantities of data on magnetic tape for later playback and printout without tying up the computer.
Display visual and aural signals in case of trouble or on the occurrence of a specific piece of information.

These are only a few of the many input-output devices available to the computer world. Another control problem which has been successfully solved is the problem of feeding continuous, or analogue, data into a digital machine. As has been explained earlier in this series, a digital machine takes step-data and works with it. Analogue, or non-discrete, information is converted to digital data by the use of an ingenious device called the digital reader.

Computers are really very stupid objects; their utility lies in the high speed with which they can perform operation and judgement functions. In the performance of judgement functions, a computer must have all the data and cannot make decisions on inadequate information as humans can.

To conclude this series, I should like to discuss some situations in which computers are used, as well as some possible applications which are now being considered. In addition to scientific calculation, computers may be used in accounting and in control functions. Some examples of accounting functions are: business inventory control, records control, and data correlation. An example of this would be to produce a daily list for a department store of all green "Schultz" pans sold. In the application of computers to control functions, we find rich ground for making some informed guesses based on present and contemplated research. We can expect some developments in the not too distant future in complete computer control of air traffic en route and at heavily loaded airports where take-off and landing problems are rapidly becoming quite serious and where human errors are causing deaths. Research is in progress, but little can be said because of security limitations. Great strides have already been taken in the mechanization of catalytic chemical plants; we may see the day when these plants are controlled by setting the desired output on a switch, and obtaining it with no human action necessary beyond that point except to transfer the finished products.

A great deal of serious thought is being devoted to another very useful accounting function that computers can perform. Imagine, if you will, going into a large library, sitting down at a screen similar to the microfilm

HOW TO DESIGN PRODUCTS TO SAVE MATERIAL AND COST

MOST products can be built stronger, more rigid with welded steel construction than possible any other way. Steel is 3 times stronger and twice as rigid as traditional gray iron. As a result, usually less than one-third the actual weight of metal is required.

Pound for pound, steel sells for a third of what gray iron costs at the cupola. This lower cost per pound plus fewer pounds needed to carry equivalent load means that initial material costs can be cut as much as 85% of prices charged for castings alone to which fabrication, of course, must be added.

In addition to its inherent superior physical properties, steel is easily formed to efficient engineering shapes such as I beams and channels. Thin wall structural sections are possible by concentrating material at outer edges in load carrying members where each pound of metal does the most good. When steel is utilized to the fullest, a product of welded construction generally can be manufactured for half the cost.

The examples show how a typical machine part was changed over from cast iron to welded steel construction. The cost saving of 50% resulted from less material and expense by eliminating several machining operations such as milling and drilling. Cleaning and painting operations in the former cast design were also avoided. The new welded steel base is both stronger, more rigid and has a clean streamlined appearance to improve selling appeal.

Latest information on designing structures to save steel and lower cost is presented in 1200 page "Procedure Handbook of Arc Welding Design and Practice". Price only $2.00 postpaid in U.S.A.

Original Cast Construction *required 41% more material. Heavier weight increased handling costs in manufacture, shipment and installation.*

Present Design in Steel *cut production cost 50% . . . New design is actually stronger, more rigid than original. Modern appearance has greater selling appeal.*

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

partners in creating

● For many years K&E has pioneered in the manufacture and development of finest quality surveying instruments. K&E surveying instruments are renowned all over the world for their superb performance under conditions of all kinds, for their magnificent workmanship and for special features that come of progressive ingenuity.

KEUFFEL & ESSER CO.
EST. 1867
NEW YORK • HOBOKEN, N. J.
Chicago • St. Louis • Detroit • San Francisco • Los Angeles • Montreal

K+E

Drafting, Reproduction and Surveying Equipment and Materials, Slide Rules, Measuring Tapes.

reader screens of today, pressing a button, and having a general catalogue appear before you. You might type the subject, author, or title of a book out on a keyboard before you, and the catalogue card for the book will appear on the screen. Another button will project any page desired of the book on the screen, and still a third will produce a complete copy delivered via pneumatic chute.

In business, a computer is sought after which will permit a certain large mail order house to type out each order as it comes in and receive an instant indication of the availability of the items ordered. Needless to say, a computer of this kind, wired to several input keyboards, would speed up operations considerably, resulting in a saving in time, money, and customer good will. The only thing preventing the start of this project is the fact that the firm in question would like to have such a computer, but does not want it enough to be willing to pay the huge initial cost involved. By the time this article is published, however, this project may have been undertaken.

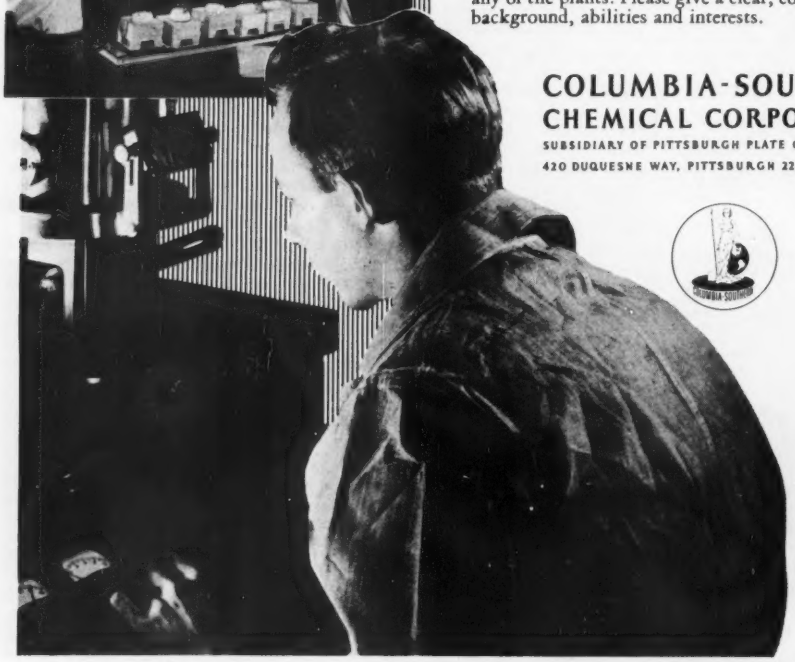
To return to control functions, by far the greatest consumer of control computers is the military, with its vast collection of gun directors, rocket controls, automatic gunsights and radar equipment. All such control servomechanisms are really small computers. Recently, a new computer-anti-aircraft gun was announced, which will pick up an enemy jet plane on its radar and blow it out of the sky without the necessity of a single human decision except, perhaps, the pressing of a *start* button.

The developments in this article seem to imply, and rightly so, that the tendency in the computer field is toward simplification and increased dependence on the computer rather than the operator. As a matter of fact, it is hoped that the day will come when general problems will be fed into the computer directly without the elaborate systems of coding necessary today. There have been developments along this line at M. I. T.'s Whirlwind recently. The machine has been programmed to accept some types of algebraic equations and produce solutions, without reference to the instruction code.

It is also hoped that the day will come when the research and development in the field of computer mechanisms will be directed toward peacetime applications, where they may free man from some of his industrial drudgery.

Making an analysis with the infra-red Spectrophotometer.

Testing action of Perchlorethylene on various metals.



Focusing the Electron Microscope on a chemical sample to be photographed.

COLUMBIA-SOUTHERN
needs men with creative imaginations

Never before in history have chemicals played such a vital part in man's life and development. And never before has any industry offered greater opportunities to the college graduate.

Columbia-Southern is one of the most rapidly-expanding chemical companies. It needs promising young graduates of scientific, engineering, and business schools. Opportunities exist at Columbia-Southern in research and development, sales, plant design, mining, construction and maintenance, and chemical production. Opportunities for technical and non-technical graduates also exist in accounting, transportation and related service fields.

Monthly sales at Columbia-Southern are now five times as large as they were only ten years ago, and the potentials are even greater for the future.

Columbia-Southern is a wholly owned subsidiary of Pittsburgh Plate Glass Company. It thus presents the *individual opportunities* of an expanding chemical corporation, plus the stability in being an integral part of a larger and diversified organization.

ACT NOW! Send for comprehensive booklet outlining the "Nationwide Opportunities in Varied Technical Fields at Columbia-Southern." Or send your application for employment to the personnel manager at our Pittsburgh address or any of the plants. Please give a clear, complete account of your background, abilities and interests.

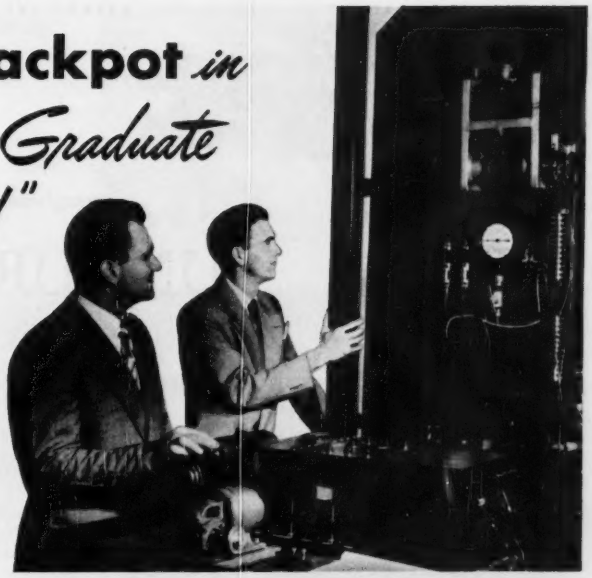
COLUMBIA-SOUTHERN CHEMICAL CORPORATION

SUBSIDIARY OF PITTSBURGH PLATE GLASS COMPANY

420 DUQUESNE WAY, PITTSBURGH 22, PENNSYLVANIA

PLANTS: BARBERTON, OHIO • BARTLETT, CALIFORNIA • CORPUS CHRISTI, TEXAS • LAKE CHARLES, LOUISIANA • NATRIUM, WEST VIRGINIA • **DISTRICT OFFICES:** BOSTON • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • HOUSTON • MINNEAPOLIS • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ST. LOUIS • SAN FRANCISCO

"We Hit the Jackpot *in* Allis-Chalmers Graduate Training Course!"



say N. W. MORELLI

Oregon State College, B.S., M.E.—1950

and

E. R. PERRY

Texas A. & M., B.S., E.E.—1950

WHILE taking the course, two engineers developed a revolutionary new circuit breaker mechanism.

"Our experience shows what *can* happen if you work with people open to suggestion. We found men of this kind at Allis-Chalmers, and it has given us a special pleasure in our job.

"We started out like most other graduates with a hazy idea of what we wanted to do. After working in several departments, we requested that part of our training be at the Boston Works of Allis-Chalmers, where circuit breakers are made."

New Design Principle

"Circuit breakers soon became an obsession with us, and we got the idea of designing a hydraulic operator or triggering mechanism for these breakers. Most of the operators for big breakers are pneumatic.

"Unsuccessful attempts had been made in the past by all circuit breaker manufacturers to build hydraulic operators. The important thing is that no one at Allis-Chalmers said, 'Don't try it—it won't work.' "

Start New Era

"To make a long story short, our study of the problem led us to the hydraulic accumulator and high speed valves being used by the aircraft industry. These had not been available when earlier attempts were made to build a hydraulic operator. With these highly developed devices to work with, we were able to build an operator that combined the best features of pneumatic and hydraulic operation. We call it the *Pneu-draulic* operator. Engineers are saying it starts a new era in circuit breaker actuation.

"This fact is important to us, but it is even more important to know that Allis-Chalmers Graduate Training Course is full of opportunity . . . and as we found out, there's opportunity right from the start."

Pneu-draulic is an Allis-Chalmers Trademark.

Low-pressure spindle for a 120,000 kw steam turbine generator. Said to be one of the largest ever built in the United States, this spindle is nearing completion in the Allis-Chalmers West Allis shops.

Facts You Should Know About the Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, or specialized equipment with which he will work, such as: steam or hydraulic turbo-generators, circuit breakers, unit substations, transformers, motors, control, pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

7. For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS AC

C-5675

ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL

Sunbury Plant of Pennsylvania Power & Light Co., Sunbury, Pa.

Pennsylvania Power & Light Company's

SUNBURY STATION

world's largest anthracite-fired steam electric plant, is "supported" by

GRINNELL HANGERS

Pennsylvania Power & Light Company at its Sunbury Plant faced the problem of providing flexible, but constant support, to main steam piping carrying superheated steam under a pressure of 1350 pounds per square inch, and at a temperature of 950°F.

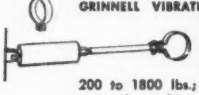
For "support" on that tough assignment . . . Pennsylvania Power & Light turned to Grinnell. And that is understandable. Grinnell is America's No. 1 supplier of pipe hangers and supports. Grinnell combines modern manufacturing with expert background knowledge gained during a century of piping specialization. Grinnell, and Grinnell alone, can offer these advantages:

- Complete "start to finish" production facilities — including research, design manufacturing, engineering and field service.
- Practical experience in every type of piping gained during the past 100 years.
- Coast to coast distribution — enabling "out of stock" purchases, anywhere.

Call on Grinnell . . . "whenever piping is involved."

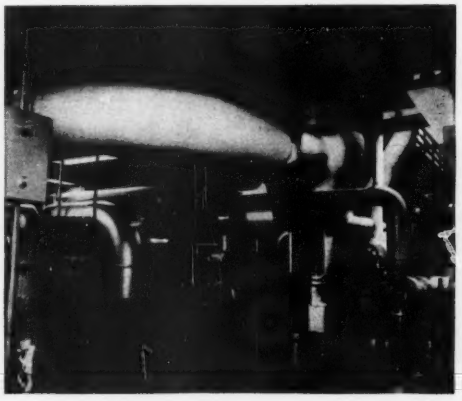
GRINNELL MODEL L CONSTANT-SUPPORTS maintain full safety factor in high temperature, high pressure systems. 3 physical structures accommodate maximum travel requirements of 2½, 5 and 10 inches; 16 sizes collectively cover numerous load ranges between 141 and 19,530 pounds.

GRINNELL PRE-ENGINEERED SPRING HANGERS — maximum variation in supporting force per ½" of deflection is 10½% of rated capacity — in all sizes. 16 sizes available from stock — load range from 74 pounds to 9000 pounds.



GRINNELL VIBRATION CONTROL AND SWAY BRACES—dampen vibration, oppose pipe sway and absorb shock. 3 sizes give full deflection forces from 200 to 1800 lbs.; have initial precompressed spring forces from 50 to 450 lbs. respectively.

Twin Grinnell Constant Support Hangers provide uniform lift for steam turbine throttle valve to prevent stresses in piping as it moves from "cold" to "hot" positions.



GRINNELL

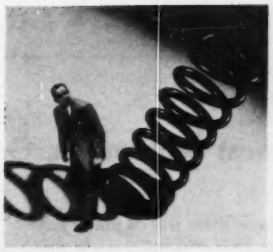
AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

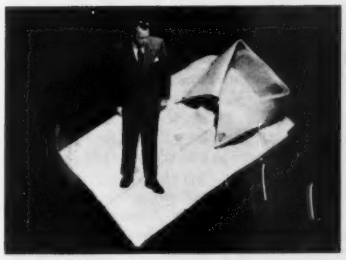
It looked impossible until they turned to

"MAN-MADE MINERALS"



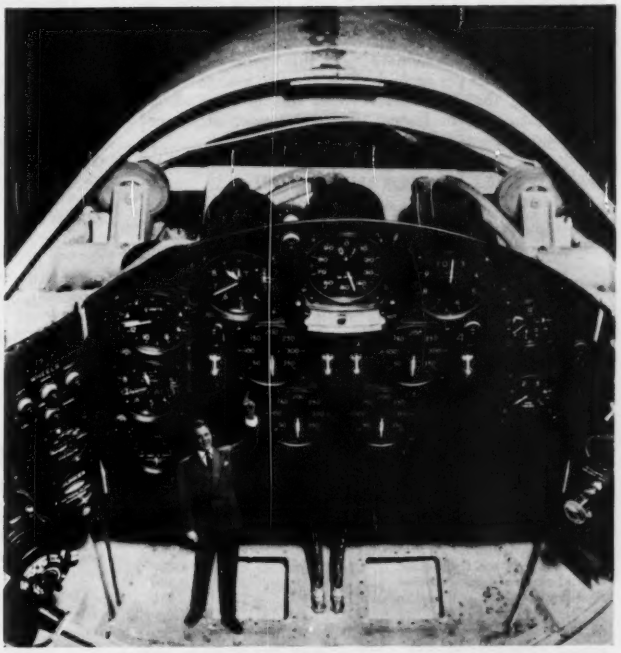
SMOOTHER RIDING gets an assist from CARBORUNDUM research. Coil springs for your car's front end are formed from steel bars heated in furnaces whose work-rests, of steel alloy, lasted six months, needed repair weekly. CARBOFRAX super refractory work-rests, at half the initial cost of alloy, last two years with no repair whatever.

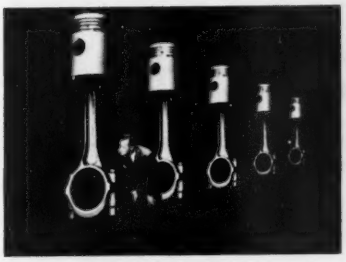
Produced by the Refractories Division



"MAN-MADE MINERALS" serve the textile industries in TEXALOX drawing roll coverings. These provide a positive, uniform grip on delicate fibres and fabrics, and are unaffected by textile processing chemicals.

Made by the Coated Products Division





MASS PRODUCTION of precision products became possible when superior man-made abrasives were developed by CARBORUNDUM. Today, *only* CARBORUNDUM *offers ALL abrasive products to give you the proper ONE.*

TEMPERATURES CHANGE DRASTICALLY in high altitude flight, but products by CARBORUNDUM prevent the danger of false instrument readings arising from this cause. Ceramic resistors of "man-made minerals" compensate for variations of temperature in many special-purpose applications.

Manufactured by the GLOBAR Division

Instruments that tell the truth at 35,000 feet
. . . metal products ground to a perfect fit
. . . delicate fabrics gently guided through production
. . . longer life for heat treatment furnace parts

These are but *samples* that suggest the great variety of work performed by minerals Nature left for man to invent. In every instance, a job is being done with convenience, speed, economy or certainty unattainable with other materials.

Your processes may well call for equipment that is strong, sharp, hard and conductive beyond the ordinary, or exceptionally resistant to heat and chemical attack. If so, you are faced with opportunities to profit with products made of silicon carbide or aluminum oxide by CARBORUNDUM.

New applications of the unique properties of "man-made minerals" are being developed constantly. Whether you are a present or a potential customer of CARBORUNDUM, or a potential member of our great engineering staff, we welcome your interest—and your inquiries.

Keep your eye on

CARBORUNDUM

TRADE MARK

for significant developments based on "man-made minerals"

THE CARBORUNDUM COMPANY, NIAGARA FALLS, N. Y.

Products by CARBORUNDUM include Grinding and Cutting-Off Wheels, Discs and Sticks . . . Coated Abrasive Sheets and Belts . . . Waterproof Abrasive Paper . . . Abrasive Grain and Powders and other abrasive products . . . Electric Heating Elements and Ceramic Resistors . . . Grain and Briquettes for deoxidizing steel and iron . . . Super Refractory Bricks, Special Shapes and Cements . . . Porous Filter Media and Diffusers—and are marketed under the following trademarks:

CARBORUNDUM • ALOXITE • MX • RED-I-CUT • TEXALOX • GLOBAR FERROCARBO • CARBOFRAX • ALFRAX • MONOFRAX • MULLFRAX

escape???

By Ernest Schurmann, G.

If man does get into space, there will be many problems that he will encounter. First and foremost, he must escape from the earth's surface and reach space. The problem is one of achieving a high enough energy to escape from the earth's gravitational potential. The escape velocity at the surface of the earth may be derived from energy considerations; this figure comes out to be 37,000 feet per second. This is quite a large figure, considering that the fastest man has gone is about 1,700 f.p.s., and the fastest that any man-made object has gone is about 8,000 f.p.s.

To get to the basic mechanics of the problem, we apply Newton's Law for a variable mass:

$$F = mdv/dt + (v - v_0)\, dm/dt$$

where $(v - v_0) = c$ = relative velocity of the mass with respect to the vehicle (i.e. exhaust velocity). Assuming no external forces (i.e., neglecting gravity) we integrate to find that the final velocity is:

$$V = c\, ln/m_0/m^f \qquad (1)$$

where m_0 = initial mass and m_f = final mass.

The value of the exhaust velocity is a function of the fuel used, as shown in Table I. The highest value

TABLE I

Oxidizer and Fuel	*Exhaust Velocity (ft/sec)*	*Specific Thrust*	*Specific Gravity of Mixture*
Liquid oxygen and gasoline	7,780	242	0.965
Liquid oxygen and ethyl alcohol	7,810	243	0.966
Liquid oxygen and methyl alcohol	7,660	238	0.895
Liquid oxygen and liquid hydrogen	10,800	335	0.330
Liquid oxygen and hydrazine	8,350	259	1.050
Liquid oxygen and ammonia	8,220	255	0.980
Red fuming nitric acid and aniline	7,090	221	1.370

of the exhaust velocity is given by a liquid oxygen and liquid hydrogen rocket. Since there has to be a high mass flow, and liquid hydrogen has a very low specific gravity, the volume needed would be extremely large. Therefore, more practical fuel mixtures would be liquid oxygen and alcohol or liquid oxygen and hydrazine. These types of fuels give exhaust velocities of the order of 10,000 feet per second. Even with these large exhaust velocities, it would take a fuel-to-gross-weight ratio of .975 to escape from the earth. This means that the empty rocket would have to be capable of carrying almost one hundred times its own weight of fuel under an acceleration of two g's. It is impossible to build such a structure. In figure 1, the maximum velocity obtainable using various exhaust velocities is plotted versus fuel to gross mass ratio.

The only way to overcome this problem of high fuel-to-gross-mass ratios is to use step rockets. A step rocket is a rocket built on top of another rocket. When the first step is burned out, it drops off. The next step continues the rocket on its way. The effect of n stages on the performance is shown by the effect on equation 1:

$$V = c\, ln\, (m_0/m_f)^n \qquad (2)$$

The effect of the number of stages on the fuel-to-gross-weight ratio to reach escape velocity is shown in figure 2. As is shown in figure 2, the fuel-to-gross-weight ratio is reduced markedly by increasing the number of stages.

One of the problems is the most efficient use of the thrust of the rocket engine. There are two ways to program the thrust; the first, to call for a constant acceleration. This has the disadvantage of forcing the throttling down of the engine, resulting in the loss of the full thrust. Also it is quite an engineering problem to throttle a rocket motor. The second method is to call for a constant thrust. This way the engine is always running at full power. There is one disadvantage to this method; the load factor (i.e. acceleration) is always increasing. The constant thrust program is the one that is used in most rocket motors of today.

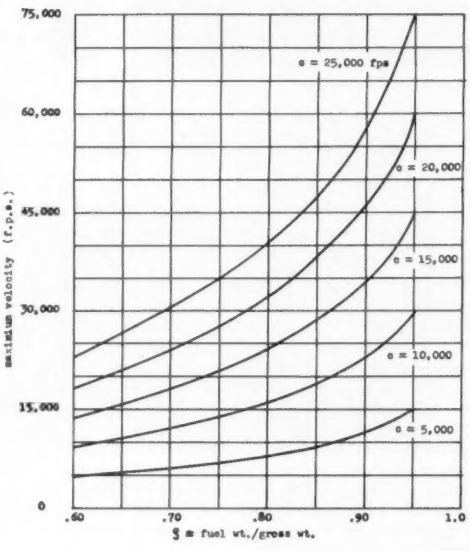
The fact that there is an atmosphere present producing aerodynamic drag is a factor that many people overestimate. For a realistic shape, drag calculations indicate that only about three per cent of the work done would be against drag, the other 97% would be the work done against gravity.

It would now be best to outline some of the theory used in step rocket design. The easiest way to do this is to define some of the basic parameters that will be used.

$$\lambda^{(n)} = \text{payload ratio} = \frac{\text{payload of nth step}}{\text{gross wt. of nth step}}$$

The superscript n denotes the nth step.

Figure 1. Maximum velocity versus fuel to gross weight ratio for various exhaust velocities.



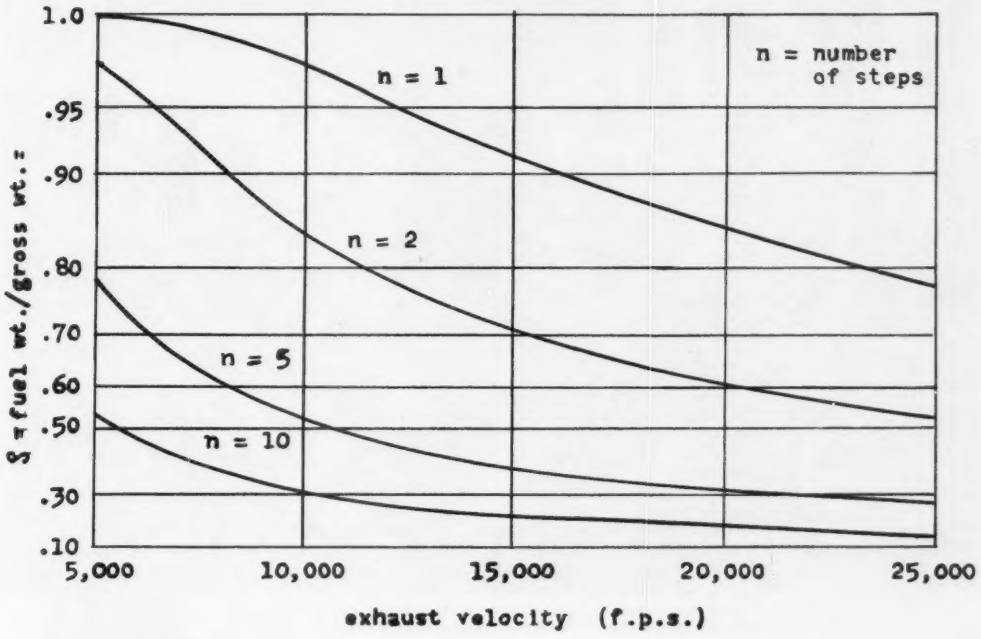


Figure 2. Fuel to gross weight ratio to reach escape velocity for step rockets.

It can be shown after sufficient manipulation that the ratio of the final payload to the initial gross weight is equal to the product of the payload ratios of each step:

$$\frac{\text{final payload}}{\text{initial gross wt.}} = \lambda^{(n)}\,\lambda^{(n-1)} \ldots . \lambda^{(1)} \qquad (3)$$

Now to carry through a preliminary design of a rocket ship; to make a useful flight into space a final payload of about 2,000 pounds would be needed. We see from figure 2 that about five steps give the maximum advantage from a step rocket. From Table I it can be seen that about the best fuel is liquid oxygen and hydrazine. We should be able to have 80% of the weight of each stage, excluding payload, be fuel. (The V-2 rocket minus warhead was 82% fuel by weight. We should be able to do somewhat better at the present time.)

If we assume that the altitude at the end of burning is six hundred miles, then the escape velocity goes down to 34,300 feet per second. If we also assume that the burning time for each stage is sixty seconds and that the acceleration due to gravity does not change much from the value at sea level, we can calculate the payload ratio λ. For our five-stage rocket, $\lambda = .1305$. This then determines the initial gross weight from equation (3):

Gross weight = 52,700,000 pounds

The maximum acceleration for our design turns out to be 8.1 g's. This value is quite high but a human will be able to sustain such an acceleration if he is in a prone position.

To summarize our rocket design:

Number of steps = 5
Fuel — Hydrazine
Oxidizer — Liquid oxygen
Weight of first step = 52,700,000 pounds
Weight of second step = 6,880,000 pounds
Weight of third step = 900,000 pounds
Weight of fourth step = 117,500 pounds
Weight of fifth step = 15,350 pounds
Payload weight = 2,000 pounds
Payload ratio = .1305
Maximum load factor = 8 g's
Exhaust velocity = 8,350 feet per second
Maximum velocity = 34,300 feet per second
Total burning time = 300 seconds

It is quite evident from our rocket design that it will be extremely costly to get our rocket ship out into space. It will take 25,000 pounds of fuel and structure to get one pound of our payload into space. This obviously adds up to a tremendous amount of money. Hence such a project is not feasible from the economic standpoint. Probably the only way out would be an atomic powered ship.

Aside from the problem of escape, meteors, sun radiation, and return to the earth's atmosphere present further difficulties. There are many more problems that need to be worked out before man can make a successful flight out into space. I hope that I have given an insight into a few of the problems that confront the designers of our first space ship.

Developed by RCA Victor, the new "45 Extended Play" record gives music lovers more music for less money plus a perfect medium for playing shorter classical works and multiple popular selections.

Twice as much music on the same size record

Another RCA achievement in electronics:

A challenging question was asked RCA engineers and scientists in 1951. How can we increase the playing time of a 7-inch "45" record, *without using a larger disc?*

Sixteen months of research gave the answer, "45 EP"—Extended Play. Public response confirmed this as *the most important achievement in the new recording speeds.* More than 2 million RCA Victor "45 EP" records were bought in the first four months of their existence!

Research leadership—your guide to better value: the ability of RCA Victor to solve the problem of more music on a "45 Extended Play" record accents the importance of research *to you.* Whether you plan to buy television, radio or any other electronic instrument, research leadership adds more value to all products and services trademarked RCA or RCA Victor.

CONTINUE YOUR EDUCATION WITH PAY—AT RCA

Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

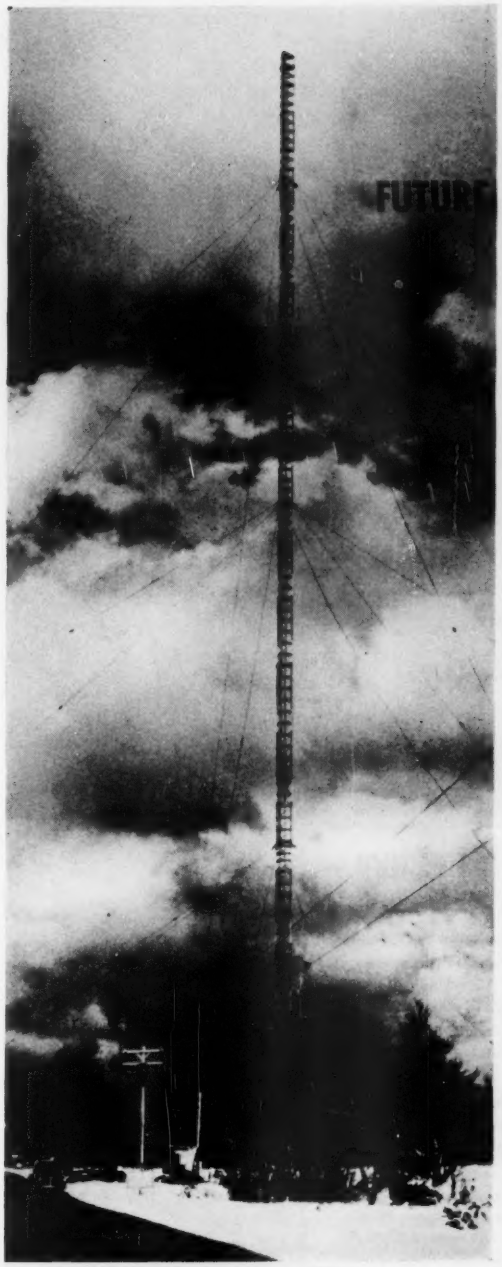
- Development and design of radio receivers (including broadcast, short-wave and FM circuits, television, and phonograph combinations).
- Advanced development and design of AM and FM broadcast transmitters, R-F induction heating, mobile communications equipment, relay systems.
- Design of component parts such as coils, loudspeakers, capacitors.
- Development and design of new recording and producing methods.
- Design of receiving, power, cathode ray, gas and photo tubes.

Write today to College Relations Division, RCA Victor, Camden, New Jersey. **Also many opportunities for Mechanical and Chemical Engineers and Physicists.**

Secret of "45 Extended Play" is RCA Victor's discovery of a new way to cut a master disc—with an electrically heated stylus. Grooves are closer. Sound quality is cleaner, clearer, more alive.

RCA® *RADIO CORPORATION OF AMERICA*

World leader in radio—first in television



A Quarter Mile Up
FUTURE JOBS ARE BEING ENGINEERED

Your future lies not in the obvious, the complete, the established. It is forming on the drawing boards, in the laboratories and within the minds of men.

Don't look to what is, but to what shall be. Fortune comes from the new.

This Air Force Radio tower, a 1218-foot equilateral steel triangle, is the tallest in the world; second among man-made structures only to the Empire State Building. It was designed and fabricated by Republic's Truscon Steel Division. The operation of this tower is government business. But its stresses and its resistances are Republic's. The engineering of this lacy pinnacle will find adaptations in the near future. They are being shaped now in the metallurgy and design departments of Republic. A quarter mile above the earth, the steel toys with gales and totes an unpredictable burden of ice. And the facts of these achievements shall be translated by men of your generation into the still higher pinnacles of the future.

Republic's Truscon Steel Division leads the world in radio towers. Republic's other divisions push forward other frontiers. No manufacturer makes more kinds of steel, nor any better. But the making of steel is only one phase of Republic. Our many divisions design innumerable products, fabricate thousands of items.

Here lies the new—the realm for young men of talent and vision.

REPUBLIC STEEL

REPUBLIC STEEL

WORLD'S WIDEST RANGE OF STEELS AND STEEL PRODUCTS

SYNTHANE—out of sight, but in the picture

Whenever you turn on television you are using a little-seen, but essential, material called Synthane.

Synthane is a laminated plastic of multiple virtues, which recommend it for many jobs in television.

Synthane is an excellent insulator, laminable with metal, hence, a good base for space-reducing "printed" circuits. Synthane is notable for low power factor, low moisture absorption, and ease of fabrication, three properties desirable for radio and television insulation. Synthane plays a supporting part in many behind-the-screen and behind-the-camera applications.

Synthane is also light in weight, strong, vibration absorbing, chemically resistant, high in dielectric strength, dimensionally stable, heat resistant to about 300°F.

There may be a place for Synthane in your product. To find out more about the possibilities of Synthane for your purpose, write for the complete Synthane Catalog. Synthane Corporation, 42 River Road, Oaks, Pennsylvania.

Synthane laminated plastics are produced under heat and pressure from laminations of resin-impregnated materials such as paper, fabric, glass cloth, asbestos, etc. Synthane plastics are available in sheets, rods, tubes, and fabricated or molded parts. Each of the many Synthane grades has a combination of useful properties.

Synthane in Television . . .

A-Television camera parts

B-Television receiver printed circuits—metal foil on Synthane sheets

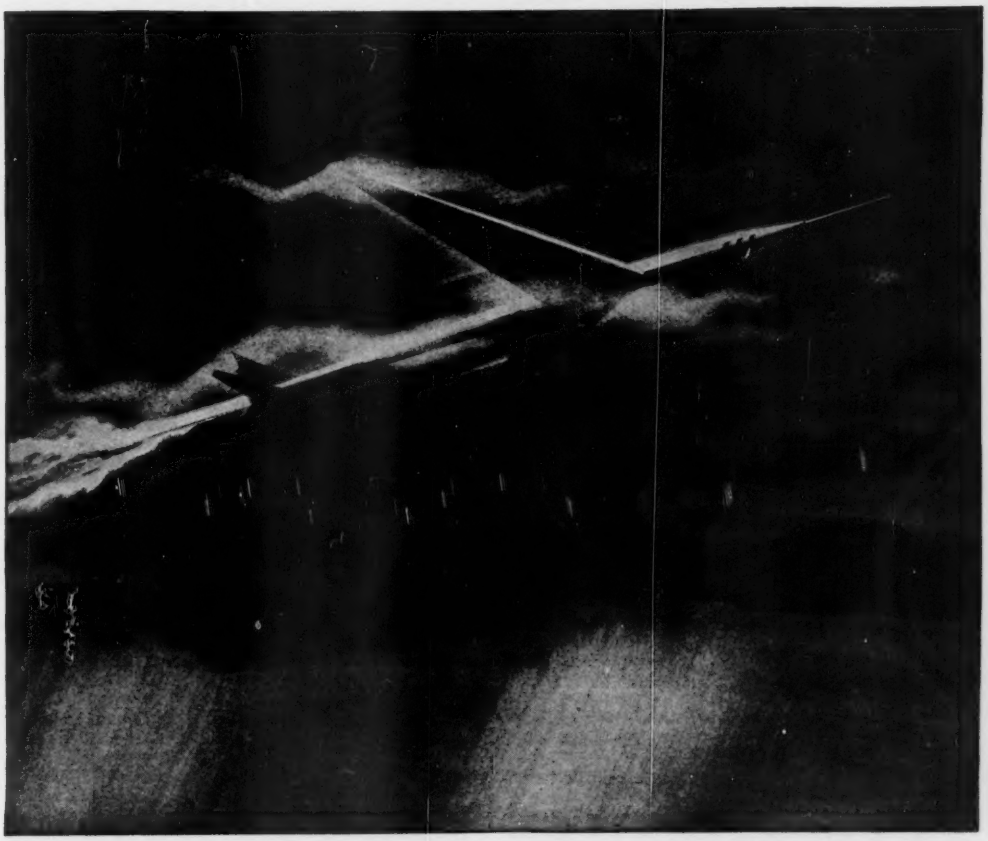
C-Channel selector switch insulation

Synthane—one of industry's unseen essentials

SYNTHANE

S

LAMINATED PLASTICS



Do you want to get ahead in engineering?

Then—after you graduate—join a company that's expanding in fields where big engineering futures lie.

At Boeing you'll find plenty of room to get ahead in such projects-with-a-future as a major guided missile program . . . research in supersonic flight and nuclear-powered aircraft . . . America's first-announced jet transport . . . and the revolutionary B-47 and B-52 jet bombers.

You'll find Boeing a stable 36-year-old company, that has grown practically continuously. For example, Boeing now employs 6000 engineers in contrast to 3500 at the peak of World War II. And although Boeing is a large concern, it is so organized that each engineer is an individual who stands out—and progresses—in proportion to his ability.

Boeing is constantly alert to new techniques and materials—and approaches them without limitations. Extensive subcontracting and major procurement programs—directed and controlled by engineers—give you a varied experience and broad contacts with a cross section of American industry. No industry, in fact, matches aviation in offering such a wide range of experience, or breadth of application—from pure research to production design, all going on at once.

Boeing engineering activity is concentrated at Seattle in the Pacific Northwest, and Wichita in the Midwest. These communities offer fishing, hunting, golf, boating and other recreational facilities. Both are fresh, modern cities with fine residential and shopping districts, and schools of higher learning where you can study for advanced degrees.

There are openings in ALL branches of engineering (mechanical, civil, electrical, aeronautical, and related fields), for **DESIGN, DEVELOPMENT, PRODUCTION, RESEARCH and TOOLING.** Also for servomechanism and electronics designers and analysts, and physicists and mathematicians with advanced degrees.

For further information, consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Washington

BOEING

the ethical dilemma of science

By A. V. Hill

(The following was an address given to the British Association in Belfast, Ireland.)

The Duke of Edinburgh concluded his Presidential Address last year with the words:

"It is clearly our duty as citizens to see that science is used for the benefit of mankind. For, of what use is science if man does not survive?"

Here was a challenge to his successor: to discuss how far science has already contributed to human betterment, how far it has provided fresh problems, dangers, and difficulties; and to suggest ways in which all who are concerned with science can help, as citizens, to make sure that its results in fact are beneficial.

As citizens: for scientists as such have no title to superior wisdom or virtue, and outside their special knowledge they are just as likely as others to be misled. The fundamental principle of scientific work is unbending integrity of thought, following the evidence of fact wherever it may lead, within the limits of experimental error and honest mistake. On this there can be no compromise. And since science is a universal interest of mankind, recognizing no barriers of race, class, religion, or opinion (provided that is honest), a necessary condition of its advance and application is one of friendliness, frankness, and equality. Goodwill and integrity, therefore, are indispensable alike to scientific progress itself and its successful employment for the benefit of mankind. Those who look to scientists as magicians, able to conjure a universal formula out of a hat, may be disappointed to find only so ancient a doctrine; and admittedly there *is* far more to science than integrity and goodwill. But these are the qualities chiefly required to utilize the opportunities, to resolve the problems and difficulties, which science has provided for present-day society.

The common phrase, "this scientific age," is all too apt to imply, with little justification, that the majority of people, at least in highly developed countries, now think and act scientifically; and, with no justification at all, to suggest that science can replace the older motives of human conduct. It is true that the external circumstances of life have been vastly altered by the applications of scientific discovery and invention, though as yet for only a minority of mankind. The future alone can decide whether natural resources and human ingenuity will prove sufficient, given statesmanship and goodwill, for the same transformation gradually to affect the whole of human society. If not, are stable conditions ultimately possible? Or will there be perpetual conflict between the "haves" and the "have-nots?" It is true also that the methods, ideas, and results of scientific inquiry have penetrated widely, if not deeply, into popular thinking and belief: the jargon at least of science is widespread, and magic and superstition are gradually losing, if not their currency, at least their respectability.

Yet such changes may have little real influence on the basic pattern of human behavior, and if witches are no longer hunted down and killed, political and racial intolerance can lead to even wilder and crueler excesses. In clearing away old idolatries there is always a danger of allowing new ones to creep in: the unclean spirit went out when the house was swept and garnished, but only to return with seven others more wicked than himself.

The improvement of man's estate by the application of scientific knowledge is one of the loftiest of adventures: but a belief that it can be achieved by scientific methods alone, without a moral basis to society, is a perilous illusion. If the methods of human experiment and racial improvement adopted by the Nazis could be regarded purely as applied biology, there might be much to say for them. But most of us believe that by abandoning a faith (which has nothing directly to do with science) in the sanctity of the human individual and of moral law, they were heading straight for disaster. Yet we shall see later the dilemma in which such scruples put us, in respect of the gravest of all world problems.

The conflict between new knowledge and traditional belief is no novelty. When Eve saw that the tree of knowledge was good for food, that it was pleasant to the eyes, and to be desired to make one wise, she took of the fruit thereof and did eat and gave also to Adam and he did eat. Which led, as you have read, to their exclusion from the garden and the warning, "in sorrow shalt thou eat of it all the days of thy life." Again and again the attempt has been made to forbid the fruit of scientific knowledge.

In 1874 in this city John Tyndall delivered a presidential address to the British Association which provoked a hurricane of controversy: the records tell us that it was denounced from every pulpit in Belfast. Yet, reading it now, one is impressed not only by its courage but by its reasonableness. It is true that he claimed that science will wrest from theology the entire domain of cosmological theory, whether of living or of non-living things; but he had previously referred to the immovable basis of the religious sentiment in human nature, bringing as he said "completeness and dignity to man." The views of Lucretius and Bruno, Darwin and Spencer, might be wrong: whether right or wrong, he insisted, we claim the right to discuss them. If today I claim the right to discuss not only the scientific facts themselves but their consequences in human affairs, I doubt whether denunciation will follow: if it does, I shall be sorry but unrepentant.

The development which has brought most vividly to the public conscience today the ethical problems aroused by the advance of scientific knowledge lies in the field of nuclear physics; and groups of scientific people in the free countries of the world are vigorously debating its various consequences, among them particularly the secrecy attached to weapons as new and devastating as those provided by nuclear fission. Atomic physics, however, is only one of many scientific developments which have brought, or are bringing, a mixture of possible good and evil about which judgments of relative value must be formed: we must not get too excited about one of them. There is no secrecy about most of these developments, they occur gradually and continuously before our eyes, we tend to accept them without question as though they were natural phe-

nomena: yet in fact the consequences of one of them provide the most solemn problem in the world. The dilemma is this. All the impulses of decent humanity, all the dictates of religion, and all the traditions of medicine insist that suffering should be relieved, curable disease cured, preventible disease prevented. The obligation is regarded as unconditional: it is not permitted to argue that the suffering is due to folly, that the children are not wanted, that the patient's family would be happier if he died. All that may be so; but to accept it as a guide to action would lead to a degradation of standards of humanity by which civilization would be permanently and infinitely poorer. Conduct usually falls short of principles: but that would be the worst reason for abandoning principles altogether.

In many parts of the world advances in public health, improved sanitation, the avoidance of epidemics, the fighting of insect-borne disease, the lowering of infantile death rates, and a prolongation of the span of life have led to a vast increase of population. Not only is the population increasing, but in many places its rate of increase is still rising: and these processes will take so long to reverse that for many years to come the shortage of natural resources, particularly of food, is bound to provide increasing deprivation and disturbance. That provides the practical motive of the Colombo Plan. In India, a Government Planning Commission in a report of July 1951 entitled "The First Five Year Plan," has dared to face the facts. A doubling in the last thirty years of the survival rate (births minus deaths) has led to a rate of increase of nearly 1½ per cent per annum, a total of 5 millions every year in a population of 360 millions.

"With all the effort that the First Five-Year Plan will represent, it will be possible barely to restore by 1955–1956 the pre-war standards in regard to food and clothing. Increasing pressure of population on natural resources retards economic progress and limits seriously the rate of extension of social services so essential to civilized existence."

The pre-war standard in fact was miserably poor, a large part of the population existed below the level of a decent life, scores of millions only just above that of famine. Yet the gigantic national effort proposed in the Five Year Plan, even if successful, may only just restore that miserable standard. Can it sustain it then if the rate of population increase continues? It is easy to answer that a higher standard of life has led in other countries to a gradually falling birth rate: but a higher standard requires a far greater charge on natural resources of all kinds, which cannot be met until the pressure of population is reduced.

In the meantime there is more than danger that the emergency will result in an overuse of natural resources, leading by land erosion, deforestation, and other factors to permanent and irretrievable loss: this has happened already, and is visibly happening now, in many parts of the world. In a special section on "Family Planning" the Indian Report recognizes that "an alteration in population trends takes at least a few generations to materialize;" and steps are suggested for the education of public opinion on the need for limitation, and for experimental efforts to be made in the application of simple methods of birth control. For its wisdom and courage in acknowledging the gravity of the situation the Indian Planning Commission deserves every support. But the problem itself has not begun to be solved, and its consequences will dominate the development of India for many years; indeed, its gravity will continue to increase. Malaria is admitted by the Planning Commission to take an annual toll of a million lives, tuberculosis of half a million. The resolute use of insecticides and anti-malarial drugs could soon reduce the former to a small fraction: tuberculosis is bound to require more effort and a longer term. Nobody would dare to say that steps to combat these diseases, and others such as cholera, to improve rural and industrial health, to increase the supply of drugs and medical equipment and services, should not be taken on the highest priority: but the consequence must be faced that a further increase of a million people per annum would result. Thus science — biological, medical, chemical, and engineering — applied for motives of decent humanity entirely beyond reproach with no objectionable secrecy has led to a problem of the utmost public gravity which will require all the resources of science, humanity, and statesmanship for its solution.

The example of India has been taken because of the sheer magnitude of the problem and because its seriousness is now admitted by humane and responsible men: but the same conditions exist already in many parts of the world and will soon exist elsewhere. It is *not* a question only of food: if a higher standard of life is to become universal, with education, communications, housing, reasonable amenities, and public health, a far greater demand will be made on all such natural resources as power, chemicals, minerals, metals, water, and wood. One is left wondering how long these can possibly take the strain. Could work supplies conceivably hold out if the present requirement per head, in the United States, were multiplied in proportion to meet the same demand everywhere — even without any increase of present population; and if so, for how long? There is much discussion of human rights. At what level can these be reasonably pitched? And do they extend to unlimited reproduction, with a consequent obligation falling on those more careful? These problems must be faced not only with goodwill and humanity, but also with integrity and courage, not refusing to recognize the compulsion of simple arithmetic. It is right that the scientific imagination should be allowed to play sometimes with the more distant future, when possibly new methods and resources may be found to solve all problems; but only on condition that our minds are not deflected from the urgent realities of the present.

By vast improvements in communications, which have made the world so small, applied science has been one of the chief agents in the present ferment of social, political, and economic thought. Can one urge, after the event, that the application was a mistake and that the majority of mankind could better have remained isolated and in ignorance? By making world war technically possible, applied science has helped to stir up national ambitions and social revolutions which, if poverty and deficiency continue without hope, may lead to major world catastrophe. Should we therefore refuse to employ science in defense of liberty and resign ourselves to a universal police state where no scruples are permitted? Are we, in scientific research, to say that some subjects may be investigated, but not others for fear of the consequences? Who then is to decide and by what international authority? And is it practical to insist that all scientific knowledge should be fully and openly disclosed, without secrecy or reservation of any kind, military or industrial? These are problems which cannot be solved by rhetoric, or by any simple formula. The purpose of setting them out is to make clear that we must face them with honesty and courage; for they will not solve themselves.

I have led you to the ethical dilemma which perplexes many of us by taking an example in which few would question either the motives of those who made the original discoveries or the humanity of their application: indeed, an example in which few could wish that

the fruit of the tree of knowledge had been left untried. It is easy to say now that side by side with the control of disease there should have been an equal and parallel effort in education, particularly the education of women as responsible citizens: for there is no possibility, if women remain ignorant and illiterate, of intelligent widespread family planning and control. But education alone would not have been enough, or indeed possible itself without a substantial measure of material and social betterment: and the expense and effort involved in this would have been indefinitely greater than in the application of medicine and hygiene, which after all has been relatively cheap. Had it been possible to foresee the enormous success of this application would humane people have agreed that it could better have been held back, to keep in step with other parallel progress, so that development could be planned and orderly? Some might say yes, taking the purely biological view that if men will breed like rabbits they must be allowed to die like rabbits, until gradually improving education and the demand for a higher standard of life teach them better. Most people would still say no. But suppose it were certain now that the pressure of increasing population, uncontrolled by disease, would lead not only to widespread exhaustion of the soil and of other capital resources but also to continuing and increasing international tension and disorder, making it hard for civilization itself to survive. Would the majority of humane and reasonable people then change their minds? If ethical principles deny our right to do evil in order that good may come, are we justified in doing good when the forseeable consequence is evil?

I remember asking an eminent Indian who had taken part in drawing up the so-called Bombay Plan of 1944 why there was no mention of the gravest problem of all, overgrowing population: he replied that his colleagues and he had indeed discussed it, but decided to leave it to God. To a biologist aware of the methods by which animal population is in fact controlled by nature, this seemed pretty poor comfort: yet there are many who really take that view, admittedly with the element of reason that we never can be sure that things may not turn up to make all our calculations wrong. Should we then just continue to do the good we see in front of us, in confidence that if our motives are humane, good and not evil will finally result? Or, taking that rather easy course, are we not showing a lack of the fundamental virtues of courage and integrity?

The dilemma is a real one, and cannot be resolved by any simple expedient. In another form it is perplexing many of those who are concerned with the development of nuclear physics, the ultimate service of which may be very great, possibly essential if our present type of civilization is to continue when other sources of power dry up; while the benefits to medicine and industry are already substantial. *But* — nuclear fission has released the threat of unprecedented violence, with the possible destruction of many millions of lives and the accumulated treasures, moral and material, of civilization. The individual conscience may tell a man to have no part in it. That is easy enough, for there are plenty of other interesting things to do, but it does *not* solve the problem. Moreover, it is possible that defensive weapons, based on nuclear fission, but not of the type intended for mass destruction, can be developed which would make armed aggression intolerably costly. What then of the abolition of secrecy? In principle, yes, for the historic and unique contribution of science to international goodwill has been in sharing knowledge regardless of race and frontier, and the chief satisfaction of scientific work, the condition of its fruitful development, is frank and free discussion. "Cast thy bread upon the waters, for thou shalt find it after many days," is wise and acceptable counsel in dealing with scientific knowledge: while "he that observeth the wind shall not sow and he that regardeth the clouds shall not reap" is as aptly applied to human relations as to agriculture. Every possible endeavor, therefore, should be made toward international agreement on sharing scientific and technical knowledge and controlling nuclear weapons: but this, like peace itself, is a concern of every citizen, not only of scientific people. It is hard enough to get international agreement in quite simple matters, such as the perilous state of the north European fisheries, where no secrecy is involved and little national prestige, and the scientific evidence is unequivocal: but we must go on trying.

Much scientific and technical advance has led to unexpected dangers and difficulties. Without our present knowledge of bacteriology and preventive medicine, gigantic armies could never be kept in the field, and land war on the recent scale would be impossible. Is medical science, therefore, to be blamed for twentieth-century war? The indiscriminate use of insecticides, by upsetting the balance of nature, can quickly do more harm than good. Radio communication may be used for spreading lies and disorder as well as truth and goodwill. Developments in microbiology, in many ways beneficent, may be used in the future for biological warfare, with effects at present unpredictable; and control by international agreement and inspection might be very difficult. The list need not be multiplied; all are aware that every new benefit to mankind provides also its own dangers, either as unexpected consequences or by deliberate misuse. Science is not alone in this: liberty may lead to license, religion can be used to inflame passions, laws can be exploited to protect wrongdoing. If scientists feel called upon to examine their consciences, so much the better: but they need not imagine that in this they are exceptional!

It has been debated whether "the scientific mind is fundamentally amoral." The real answer is that there is no such a thing as "*the* scientific mind." Scientists for the most part are quite ordinary folk. In their particular scientific jobs they have developed a habit of critical examination, but this does not save them from wishful thinking in ordinary affairs, or sometimes even from misrepresentation and falsehood when their emotions or prejudices are strongly enough moved. Their minds are no more amoral than those of surgeons, lawyers, or scholars. As investigators most of them realize that their function would be stultified were they to introduce moral data into a scientific argument. A surgeon is not required, or indeed allowed, to consider whether it would be better for the world if his patient died under the operation; he has only to carry it out with skill, care, and integrity: but it would be foolish to conclude that the surgical mind is amoral. The surgeon himself, as a human being, has to make moral judgments: but he does so outside the operating theater. So it is with scientific people. Like all good citizens they must take account of ethical considerations, and the chief of these — as with other good citizens — are of integrity, courage, and goodwill. Integrity forbids them to allow feelings of any kind to obscure facts, but that does not make them amoral: after all, integrity is the first condition of morality.

In the practical world of today, complete abandonment of secrecy, in government and industry, is out of the question. The advantages to international relations, and to general scientific progress, of the greatest possible freedom are evident; to these can be added the impossibility, in a free democracy, of keeping the best people unless the conditions of their work are congenial. If

scientific men consistently avoid jobs which seem to them to fall short of reasonable freedom, they will force changes of organization so that only necessary secrecy is maintained. The penalty of filling an organization, governmental or industrial, with second-rate people, cheerfully amenable to unnecessary restrictions, is far too evident in its result on efficiency to be tolerable for long. The cure, therefore, is largely in scientists' own hands. In this, as in many other aspects of their work, moral considerations come in, and the only way to resolve the dilemma which is in so many minds is to discuss it frankly. To neglect it altogether is not amoral but immoral. It is the duty of all of us as citizens to consider the ethical basis of our work.

Today when the public importance of science and its popular esteem may turn some people's heads it is well that scientists should realize that the prestige of science is not their personal property, but a trust which they have an obligation to pass on uncompromised to their successors. The popularizing of genuine science is an important public service; we should all be ready to take our part in it according to our powers: but to use the general prestige of science as a bait to attract attention to pronouncements on other topics, for example on politics or religion, is a disservice both to science and the public. As a citizen I need no more justification than any other citizen in saying what I like about such things: but I have no right to pose as a representative of science in discussing them. In the days when the representatives of religion claimed supernatural knowledge of the natural world it was necessary to insist, as Tyndall did, that the natural world belongs to science. Fortunately those days are past. If they now claim that the facts and trends of overpopulation are not what we say, we can argue about that as a scientific question: but if they insist that its consequences should be left to God, they must allow us as citizens to take the opposite view. If political pressure were applied in any way to force conformity to particular scientific theories, as happened in Germany and is happening now elsewhere, then one's right and indeed one's duty would be clear, alike as citizen and as scientist. But the nature of political institutions and the policies of political parties are not scientific questions and how I choose to vote has nothing to do with science. Indeed, curious as it may seem, the spectrum of political opinion of scientists in Britain is much the same as that of other similar groups: though the loudspeakers are generally tuned in to one particular wave-band.

Some seventeen hundred years ago there crystallized out, from many centuries of experience of the human problems and ethical necessities of medicine, the so-called Hippocratic Oath. The obligation of integrity and trust; the insistent claim of suffering; the care of mothers and children; solicitude for the old and weak; the sanctity of human life: these are as vital a part of medical tradition as its science and its art. Practice, it is true, may lag behind principles, but at least such failure is regarded as discreditable; and it is hard to imagine any kind of civilization in which the ethical principles of medicine were disregarded. That is one reason why the future possibility of biological warfare is particularly repugnant. Today science finds itself, unexpectedly and without those centuries of tradition and experience, in a position no less important to the community than medicine: and its ethical principles have not yet clearly emerged.

Every candidate for admission to the earliest of American learned associations was required to answer yes to the question, "Do you love truth for truth's sake, and will you endeavor impartially to find . . . it for yourself and communicate it to others?" That affirmation might have its place in a modern scientific version of the Hippocratic Oath. But again the same dilemma arises — "endeavor impartially . . . to communicate it to others." Apart altogether from considerations of national security, in many fields today much of the best research is done, and done increasingly, in industrial laboratories. Those who have seen and admired such work, and the people who do it, cannot but applaud the foresight which made it possible. But if all the results are to be communicated at once and impartially to others, could directors and shareholders be reasonably expected to continue their support? Indeed, if an industry were nationalized could it afford to give away its secrets to competitors abroad? Not in any real world in which a nation must remain solvent and industry must depend for success on the rapid application of new knowledge. The dilemma must be met by reasonable compromise, of which, perhaps, the most hopeful sign today is that many of the directors of industry come up through research departments. A friendly and familiar contact between management and research, and between industrial and outside scientists, can reduce this particular dilemma to manageable size.

A graver problem is provided by research under government, when considerations of security come in. In the emergency which became evident in 1935, the secret development of radar for purposes of air defense aroused no obvious pangs of conscience; and many other developments come in that class. But the surest of military maxims is that counter-attack is an essential part of defense; to limit scientific methods to defensive weapons would be to insure defeat, indeed it is quite impracticable. But let us be realists; so long as offensive weapons may be used, the part played by the scientist is no more immoral than that of the engineer, the workman, the soldier, or the statesman, and the attitude of "holier-than thou" is unbecoming. We all bear, as citizens, an equal responsibility. But is it practical to suggest that all scientists in all countries should agree, and hold to their agreement whatever happens, to take no part in research on offensive weapons, or at least should endeavor impartially to communicate its results to others? The answer is evident. There are individuals in all free countries who find such work intolerable. In those countries their scruples are respected and they are at liberty to do something else; but let them not imagine that the problem is solved that way, or that those who think otherwise are necessarily stupid or immoral. The first condition of freedom is freedom of conscience, and the scientist has the same right to that as any citizen: but freedom does not extend to giving away other people's property, whether of goods or knowledge.

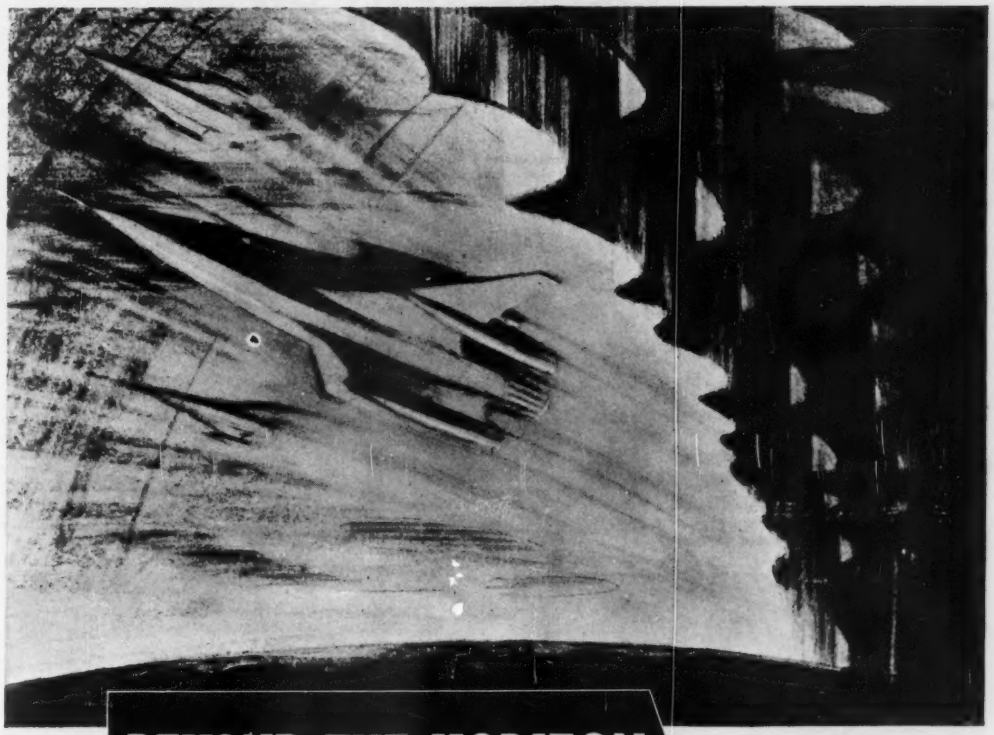
There seems to be no simple answer to the riddle. All knowledge, not only that of the natural world, can be used for evil as well as good: and in all ages there continue to be people who think that its fruit should be forbidden.

Is there really then any special ethical dilemma which we scientific men, as distinct from other people, have to meet? I think not: unless it be to convince ourselves humbly that we are just like others in having moral issues to face. It is true that integrity of thought is the absolute condition of our work, and that judgments of value must never be allowed to deflect our judgments of fact. But in this we are not unique. It is true that scientific research has opened up the possibility of unprecedented good, or unlimited harm, for mankind; but the use that is made of it depends in the end on the moral judgments of the whole community of men. It is totally impossible now to reverse the process of discovery: it will certainly go on. To help to guide its use aright is not a scientific dilemma, but the honorable and compelling duty of a good citizen.

MORE AIRCRAFT ENGINES
bear this emblem than any other

Wherever you go in the aircraft world, you'll find this emblem—the acknowledged symbol of dependability. It's carried by big bombers, medium bombers, light bombers—by all types of commercial transports—by flashing jet fighters. In a field where only the best is good enough, it stands for outstanding engineering achievement. If you would like to work for the company with a future—in an industry with an unlimited future—set your sights on Pratt & Whitney Aircraft.

Pratt & Whitney Aircraft
DIVISION OF UNITED AIRCRAFT CORPORATION
EAST HARTFORD 8, CONNECTICUT U.S.A.



BEYOND THE HORIZON....

Progress in reaction-motor propulsion becomes possible only as the metallurgist supplies new alloys to withstand the stresses, temperatures, and corrosive attack developed by new rocket fuels.

Molybdenum additions to many alloys are known to improve strength at high temperatures. For this reason Molybdenum will be used more and more in the reaction motors of the future.

Climax furnishes authoritative engineering data on Molybdenum applications.

Climax Molybdenum Company
500 Fifth Avenue · New York City 36 · N.Y.

MOLY

Uniformity gained by "Centrifugal Casting"

The great majority of cast iron pressure pipe produced today is cast centrifugally, in metal or sand-lined molds.

When this mechanized process was introduced 27 years ago, its potentialities for improved production controls were evident. For human fallibility was largely replaced by machine accuracy based on scientific principles.

The improved production controls made possible by the centrifugal casting process have long since been realized. Hundreds of millions of feet of centrifugally-cast-iron pressure pipe are now in service. All of this pipe is more uniform in metal structure, in wall thickness, and in concentricity, than pipe not centrifugally cast.

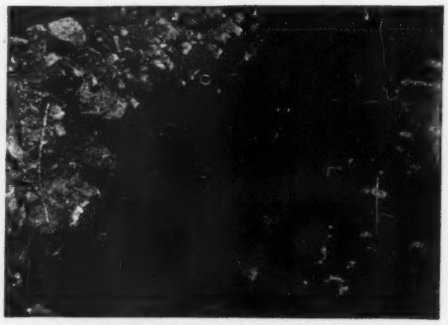
Better production control means better pipe; it results in greater uniformity of quality.

Production controls in cast iron pipe foundries start almost literally from the ground up with inspection, analysis and testing of raw materials; continue with constant control of cupola operation by metal analysis; and end with rigid tests of the finished product.

By metallurgical controls and tests of materials, our members are able to produce cast iron pipe with exact knowledge of the physical characteristics of the iron before it is poured into the mold of a centrifugal casting machine.

Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction.

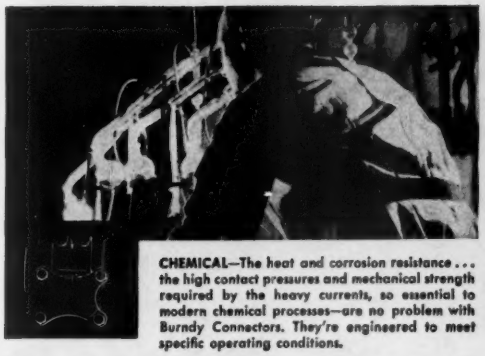
Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Avenue, Chicago, 3, Illinois.



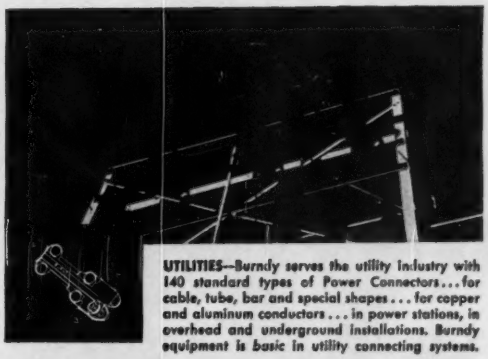
Section of 114-year-old cast iron gas main still in service in Baltimore, Md.

CAST IRON PIPE SERVES FOR CENTURIES

Wherever there's electricity... you'll find Burndy connectors on the job!

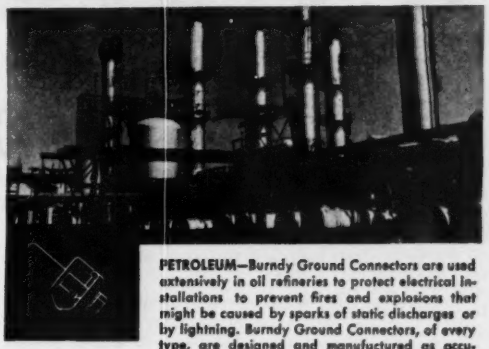


CHEMICAL—The heat and corrosion resistance... the high contact pressures and mechanical strength required by the heavy currents, so essential to modern chemical processes—are no problem with Burndy Connectors. They're engineered to meet specific operating conditions.



UTILITIES—Burndy serves the utility industry with 140 standard types of Power Connectors... for cable, tube, bar and special shapes... for copper and aluminum conductors... in power stations, in overhead and underground installations. Burndy equipment is *basic* in utility connecting systems.

MINING—Underground heavy-duty wiring systems must be protected against dampness, vibration, dust. Where a short circuit might cut off fresh air, stop the shaft elevators, throw out the lighting, interrupt pumping, or even cause an explosion—unfailing operation of the electrical installation is literally a matter of life or death. Leading engineers specify Burndy Connectors.

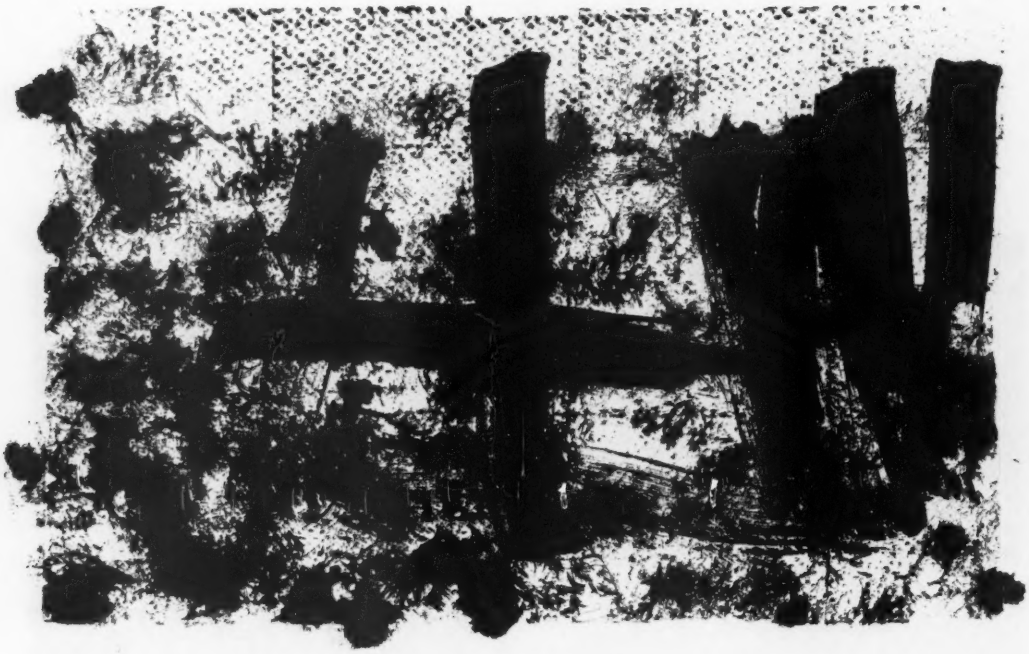


PETROLEUM—Burndy Ground Connectors are used extensively in oil refineries to protect electrical installations to prevent fires and explosions that might be caused by sparks of static discharges or by lightning. Burndy Ground Connectors, of every type, are designed and manufactured as accurately as those which are called on to carry current continuously.

Burndy Connectors are specified because of their superior performance in joining, terminating, clamping, and grounding every size and functional variety of electrical conductor—from the smallest home wiring circuit to the largest industrial installations. Burndy engineering is continuously developing more and more efficient connecting methods. *Engineering graduates and students are welcome visitors at Burndy Connector Headquarters.*

BURNDY

BURNDY ENGINEERING COMPANY • NORWALK, CONNECTICUT • BURNDY CANADA LTD., TORONTO, ONT.
"WORLD'S LARGEST MANUFACTURER OF ELECTRICAL CONNECTORS"



science and sciencibility

By Arnold Levine, '53

Since the turn of the century, physics has divorced itself from the Newtonian concepts of time, space, and force, and replaced them with notions which, if they do not seem bizarre, at least appear foreign to the layman. The variability of mass with velocity, the Riemann metrical structure of space, the contraction of bodies with velocity, the identity of mass with energy, the invariance of the velocity of light in vacuum, all found birth in Einstein's "Relativity." These phenomena came in for sharp attack from lay philosophers such as Bergson, Broad, and others, and are still treated with incredulity by many. The trouble seems to arise from the fact that by the time a man begins to philosophize, he has a lifetime of habit etched upon his convictions. It is difficult to remove the belief in well-kept notions and to replace them with new ideas, couched in the incomprehensible language of mathematics. It is much easier to retain the old ideas, and call the new ones "mathematical fictions," as Bergson did.

To present the philosophic import of Einstein's theory to the layman, it is necessary, therefore, to meet him on his own grounds and offer arguments practically devoid of mathematics. Of course, the arguments, like those of the lay philosopher, are heuristic in nature, and as such lose their importance in scientific work.

We start with the crude facts, those which lead us to the formulation of spatial geometries, time, force, and causality within our immediate environment.

Space. The notion of three dimensional space arises from a combination of visual, tactile, and motor responses. If we could imagine ourselves bereft of all motor responses, space would assume a two-dimensional quality. We could look up, down, to the right or left or straight ahead, but we could not move ourselves nor accommodate our vision to differences in distance. We would then see objects crossing our field of vision, but would certainly have no way of determining relative distances.

Assuming, then, that three dimensional space arises because of the accommodations of perceptual apparatus, how does a rational construct of space or geometry come about? If a solid body moves from one resting place to another, the accommodation of our perceptions is the same as if we moved in the opposite direction while the body stood still. Thus arises our notions of motion and congruency. We move with respect to a body when our perceptual accommodations are accompanied by muscular accommodations. The body moves with respect to us, when the perceptual accommodations are present, but the muscular ones are absent. An important point to notice here is the habit of human beings to externalize. We associate the word motion with our muscular movements which

work in conjunction with certain special accommodations of the senses. The association of the word motion is so strongly allied with perceptual accommodations that when the accommodations of the eye are caused by the motion of some external body, we assign the word motion (originally assigned to our muscles) to the external body also. This characteristic (externalizing) will be shown to be of great importance.

The concept of congruency arises in the following way. If a solid body moves from one resting place to another, in order to receive the same totality of impressions we originally received from the body, all we need do is move to the same relative position we originally held with respect to the body. If we have two solid bodies of identical shape and structure, and move one, we can now receive the same totality of impressions by moving to either one of the two places where the bodies are located. We know that these bodies are not deformed in transportation (assuming that our perceptions are not deformed in a compensating manner). We also know that it matters little in which direction we move the bodies. The deformity will still not take place. Thus, space is isotropic. Since space is isotropic, we can formulate general laws concerning it. Therefore, geometry is possible.

Notice that what we have said above applies only to solid bodies. If there were no solid bodies, but only bodies which deformed upon moving, such as liquids, we could know nothing of congruency and isotropy. This led the mathematician, Poincaré, to state, "If there were no solid bodies in nature, there would be no geometry."[1]

The advantage of the above analysis enables us to visualize worlds of more than three dimensions. If our concepts of three dimensional space, congruence, and isotropy arise from a resumé of the accommodations of our senses, one can visualize beings, either built differently than we are, or living in a differently constructed world. Under such conditions an entirely different geometry would be derived, possibly one of a greater number of dimensions. The following is a favorite example.[2]

Suppose a world is enclosed in a great sphere, and subject to the following laws:

The temperature is not uniform. It is greatest at the center, and diminishes in proportion to the distance from the center, to sink to absolute zero when the sphere in which this world is enclosed is reached. Let us suppose furthur that all bodies have the same coefficient of expansion, that all bodies are always in thermal equilibrium with their environments. A movable object then becomes smaller and smaller as it approaches the surface so that, though the world is limited, it appears infinite. If, for us, geometry is the study of the laws according to which solid bodies move, for these imaginary beings it will be the study of the laws of motions of solids distorted by the differences of temperature just spoken of. Add another hypothesis; that light passes through media diversely refractive and such that the index of refraction is inversely proportional to the distance from the edge of the sphere. Light will then travel in circular paths. It is seen, then, that there are no "solid" bodies, but that the bodies deform to a definite law, that congruency still exists, but it is a strange existence, out of which evolves a geometry entirely different from ours, a non-Euclidean geometry.

Four dimensional space is imaginable in the following way. A combination of perceptions leads to laws of three dimensional space. One of these perceptions is the two-dimensional perspective of a three-dimensional body on the retina.

Let the various perspectives of the same object succeed one another, and the transition from one to the other be accompanied by muscular sensations.

Nothing prevents us from imagining that these operations combine according to any law we choose, for example, so as to form a group with the same structure as that of the movements of a rigid solid of four dimensions.

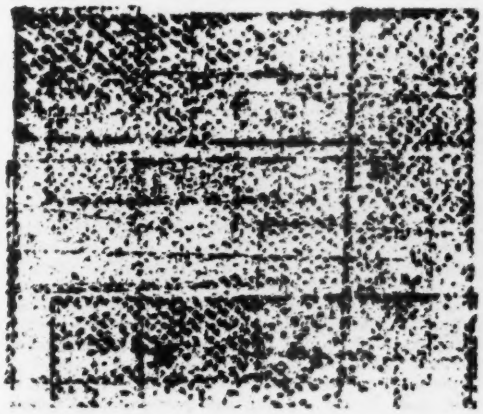
It is seen that geometry arises through the experiences of our senses, but it is not inconceivable that our senses may present a picture only of our immediate environment which does not hold outside of it.

Time. Rhythm is a dominant feature of the internal life of a human being. The beating of the heart; the contraction of the arteries, breathing, periodic hunger pangs, all give a sense of change and repetition; all contribute to the concept of the congruency of time or the equality of durations. Growing old gives the impression of a one way time flow, an irreversibility of time. However, these psychological time durations are often different for different people. One may feel that time is flying while another may believe it is just plodding. For the sake of science, the primitive notion of time must be made objective, so that it can be measured to the agreement of everyone. But first we must deal with the concept of force.

Force. In high school, force is usually defined as a push or a pull, indicating that this concept is also primitive in nature. It is once again a concept arising out of muscular action. We feel a "strain" on our arms when we pull or push. This strain is "force." Such a notion is obscure for the purpose of science, but it points the way for definition. Associated with force is the concept of matter, and cause and effect. We know that when we exert a force something usually happens. We step on a paper cup and it folds up, or pull on a door knob and the door opens. We associate force as the cause producing some effect, and externalize the concept, so that whenever one body pulls or pushes on another, we say that one body exerts a force on the other. In the primitive concept, force arises out of matter acting on matter. Therefore, included in this definition of force should be the idea of matter and motion.

Many definitions were made, but none of them enabled us to construct a logical universe as did Newton's Force = mass × acceleration. Newton derived this law from observations on astronomical bodies, and, thence,

[1] Page 75, "Science and Hypotheses," 1913, Science Press.
[2] D'Abro: "Evolution of Scientific Thought," Dover Publications, 1927.
Poincaré: "Foundations of Science," Science Press, 1913.



used it as a postulate, the foundation of classical mechanics. There is nothing sacred about this law. All will agree, if it were to come into conflict with other observations, it would have to be replaced. And with it, perhaps, its underlying assumptions, the invariance of mass with velocity, and the absoluteness of accelerated motion, to which we will come soon.

Returning to the notion of time, we find that we are now capable of setting up a definition in terms of the above law, Newton's law of inertia. This principle enables us to anticipate that if a perfectly rigid sphere, submitted to no external forces, is rotated without friction on an axis its angular rate of rotation will be uniform or constant. A near approach to the above criterion is given by the phenomenon of the earth's rotation. But for extremely accurate work, the system is not ideal. Suppose we elected to define time by entirely different methods. We might appeal to the vibrations of the atoms of some element. The intervals of time would be marked out by successive beats of the atom, and would be measured by the wavelength of the radiation. We might also proceed in terms of radioactive processes. It is well known that, when measured by ordinary clocks, the rate of disintegration of radium appears to follow an exponential law, and is not affected by temperature or pressure. Thus, the phenomenon may be regarded as being in an ideal state of isolation, and can be used as a clock.

There are many ways of determining time. There are two things to be noticed. Once we have defined time objectively, we must remember it is no longer the same as psychological time. Psychological time is a "sense" of something. At best, it is obscure sense of no use in describing the world, real or imaginary. Once made objective, time may not be the same for all phenomenon. There may be one standard in mechanics, one in optics, one in electromagnetics, and so forth. Nevertheless, and this is the second point, these standards have been chosen to insure simplicity in describing the laws of nature, and are, in this sense, only conventions, chosen because of expediency.

We have taken the crude concepts of force and time and imparted objectivity to them. The same is true of geometry. We have taken geometry, recognized it as a set of concepts arising out of association with our immediate environment, and formalized them by setting them down in some order. We are assured, however, that there is nothing sacred about these concepts. Should they come into conflict with observation, we would have to abandon them. With this attitude in mind, we can proceed.

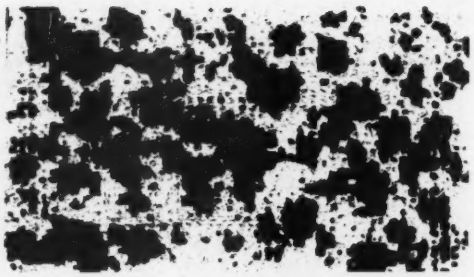
For all the sophistication of Newtonian mechanics, the underlying assumptions arose out of the crude facts. Mass was considered invariant, time was a concept distinct from space, and space itself could be described as Euclidean. Let us now consider notions of both space and time, uniform velocity and acceleration. Let there be a coordinate system (1) traveling with a constant velocity v with respect to coordinate system (2). Then, the relationship between a point X_1 in (1) and X_2 in (2) is:

$$X_1 = X_2 - vt \quad (t \text{ is time})$$
$$t_1 = t_2$$

If $F = \frac{d^2X_2}{dt^2} m$ in system (2), we see by differentiating the above equation twice that

$$m\frac{d^2X_1}{dt^2} = m\frac{d^2X_2}{dt^2},$$

so that the law of inertia remains invariant in all systems traveling with a constant velocity. Thus, there is no way of determining which is the *absolute* velocity,



since all phenomenon are the same in each. We can say just as easily that system (2) is traveling at a uniform velocity $-v$ with respect to system (1). The contrary is true of accelerating systems. Suppose the earth was always covered with clouds, so that we could never tell that we were rotating by using other bodies as reference. We could still determine our absolute rotational acceleration by measuring centrifugal and coriolus forces, or by the Foucault pendulum experiment. Here is a dilemma. One can never ascertain absolute velocity, but one can always determine absolute acceleration. Suppose there was no absolute space, a space in which absolute motion was permitted, then acceleration can never be determined absolutely. But we know this is not true. If then there is absolute space, we can measure absolute velocity. But by the very nature of Newton's equations we cannot. Are there then two spaces for each type of motion? The idea is not pleasing at all.

It was thought that the way out of the dilemma lay in the field of optics. It was found that laws of electrodynamics were not invariant, but were different in systems traveling with different velocities. Thus, one should get different results from the same optical experiments when traveling with different velocities. It was thought possible, then, to discover the magnitude of the velocity of the frame by means of optical experiments.

All such attempts failed. Together with these failures, the discovery of radioactive particles and the apparent increase in the mass of high speed particles, the failure of classical mechanics to explain the laws of black body radiation, the failure of Newton's laws to explain odd behavior of the planet Mercury, and so forth, led many scientists back to an examination of the fundamentals of physics. It was finally Einstein who rectified the problem, and introduced a new structure of the universe to replace the crude one which was the basis of classical mechanics.

The basis of the new construct was the postulate of the invariant velocity of light. "Light waves must travel with the same invariant speed in a frame traveling with constant velocity when this speed is measured by the observer located in that frame." One might ask: "What has happened to the variance of electromagnetic laws with a change in systems? If light has the same velocity in all systems, then surely the laws of electromagnetics are invariant." If one is at rest with respect to an electron, there is only an electric field set up. If the electron is moving with respect to the observer, a magnetic field is also observed. In this sense the laws are not invariant. But if one moves along with the electron, he will no longer measure the magnetic field, but will obtain the same results as when he was moving at some other speed. The speed of light must be "measured by an observer traveling in the same frame." Using this postulate and simple

algebra we find that the equations relating distances in two coordinates moving with a uniform relative velocity is not

$$X_1 = X_2 - vt \quad t_1 = t_2$$

but

$$X_1 = B(X_2 - vt) \text{ where } B = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_1 = B\left(t_2 - \frac{vX_2}{c^2}\right) \quad c = \text{velocity of light}$$

Thus, it appears that time does not "flow" at the same rate in systems traveling at different velocities, as was thought true in classical mechanics. Time is no longer a dimension independent of distances, as the equations show.

It is also to be noted from the first equation that as the relative velocity is increased, a rod along the direction of X_1 is shortened.

Here we recall that classical science, believing in the absoluteness of time, assumed that events which occurred "now" anywhere throughout space would continue to occur in the same simultaneous fashion regardless of the motion of the observer. Obviously, as the equations show, this cannot possibly be true, for time measurement is dependent on the velocity. Some lay critics, such as Bergson, alarmed by the abandonment of crude facts, endeavoured to maintain that from a purely mathematical standpoint the systems of measurement of relativity might confer greater simplicity on the purely mathematical treatment of the equations of electrodynamics, but that in no case was it permissible to assume that the anticipations of the theory could ever correspond to what we should actually measure with right rods and ordinary clocks. But if this were true, then ordinary clocks and right rods used in experiments to confirm Einstein's theory would give answers that would destroy the theory. This is not what has happened and Einstein has been vindicated.

Using the postulate of invariance, the two equations above can easily be derived. These two equations have shown us that our original crude notion about the independence of time and space is incorrect. It is impossible to show, in so short a space that relativity also shows that mass is dependent on velocity. Thus, force is no longer equal to a constant times the second derivative of a distance, but is the derivative of the mass multiplied by the velocity. Now, one may ask about the validity of cause and effect. If time is different for different systems, is it not possible that one might see an event occur before another, while someone else in some other system might see the second event occur first, and so see cause and effect reversed? For instance, in one system a man might see a book drop to the floor, while in another the book may seem to rise up from the floor. We will see that Einstein's theory does not reach that result, and that cause and effect is still a valid concept.

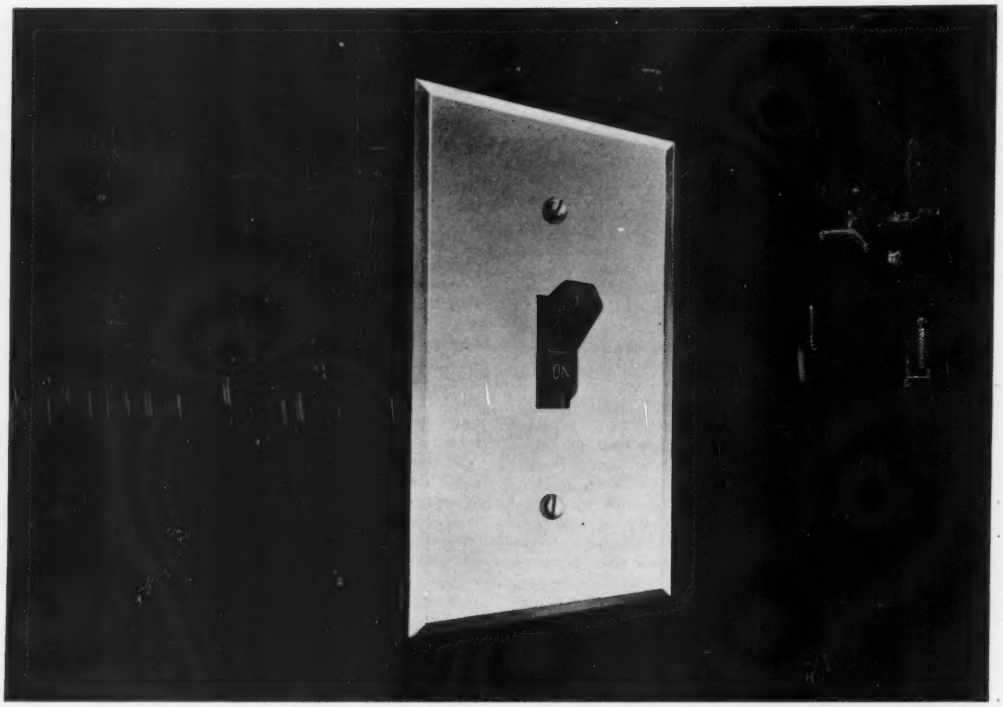
The division between events whose order of occurrence is absolute and those whose order is relative is obtained as follows[1]: Whenever it is possible for a ray of light to pass from one event to a second event, leaving the first event at the instant it is produced and reaching the second event before or even at the instant at which it is produced, the time sequence of the two events cannot be reversed by relative motion; it is absolute. This insures that, wherever a casual connection is apparent in one system, it is apparent in all of them.

If our crude ideas of space, time, and matter do not hold, does our geometry of space, our Euclidean geometry hold?

Again we find our senses have betrayed us. Space is not Euclidean in nature. Because of lack of space it is impossible to go into any discussion of this fact. It is apparent, though, that Euclidean three dimensional geometry, must be incorrect, for it indicates no relationship between time and metrics, a relationship we know holds in the real world.

In conclusion, it is only necessary to point out that Einstein has finally liberated us from the systems arbitrarily set up by our senses. The work of the physicist will be more difficult in the future because of the rich imagination needed in constructing a world so different from the senses. It will also make those not trained in the sciences more confused as to the nature of the universe. But laymen must not criticize the philosophy of the theories until they fully understand their implications. It is obvious, then, that for a man to be a philosopher in the future, he must be a man with a scientist's knowledge.

[1] Absolute means the same for all systems. Relative means depending on velocity.



KEY TO POWER...

It's just a simple switch. Yet it is the key that will unlock the energy generated by America's 20-billion dollar electric power industry.

Whether it's to light a room or a city . . . to start a kitchen mixer or a rock crusher . . . to heat milk for the baby or melt steel in an electric furnace . . . switches make you master of unseen electrical energy.

KEY TO PROGRESS...

Because myriads of scientists, physicists, engineers and designers have developed equipment to generate and utilize electric power, American workers produce more, earn more and enjoy a higher standard of living than those of any nation in the world.

Important, too, is the interchange and distribution of the ideas which have made this progress possible . . . the job of America's all-seeing, all-hearing and reporting Inter-Communications System.

THE AMERICAN INTER-COM SYSTEM...

Complete communication is the function, the unique contribution of the American business press . . . a great group of specially edited magazines devoted to the specialized work areas of men who want to manage better, design better, manufacture better, research better, sell better, buy better.

COMMUNICATION IS OUR BUSINESS...

The McGraw-Hill business publications are a part of this American Inter-Communications System.

As publishers, we know the consuming insistence of editors on analyzing, interpreting and reporting worthwhile ideas.

We know that businessmen, in order to keep abreast of their jobs, subscribe to—pay for—McGraw-Hill magazines that are edited for their specific business interests . . . for the editorial pages tell "how" and the advertising pages tell "with what."

McGRAW-HILL PUBLISHING COMPANY, INC.

ABP 330 WEST 42nd STREET, NEW YORK 36, N. Y. ABC

HEADQUARTERS FOR BUSINESS INFORMATION

McGRAW-HILL FOR BUSINESS

Things are different—up there!

You would be amazed at the tricks nature plays in the stratosphere

As aviation progress has carried man farther into the upper air, he has found that nature has many tricks up her sleeve in the stratosphere. Many things that worked well on the ground wouldn't do as well, or failed completely, in the space beyond the clouds. Things are truly different up there.

CARBON BRUSHES ARE AN EXAMPLE—These brushes are the contact points that carry electricity between moving and stationary parts of motors and generators. They're in electric razors, sewing machines, huge diesel locomotives—and in modern aircraft.

THEY COULDN'T STAND ALTITUDE—Today's high-flying planes require literally hundreds of small electric motors and many carbon brushes. Here was one of nature's quirks, for brushes which worked well on the ground and at lower altitudes couldn't take the thin, dry air of the stratosphere. They'd spark and quickly disintegrate. And if the brushes failed, the motors also would fail.

UCC FOUND THE ANSWER—The people of Union Carbide attacked this problem. Through research they developed special carbon brushes that worked uniformly well at all altitudes, making stratosphere flying a practical reality.

OTHER AIDS TO FLYING—Better carbon brushes that keep motors and generators running, alloy metals that stand the terrific heat of jet engines, plastic insulation for high-altitude wiring, and oxygen that provides the breath of life in the upper air—these are but a few of the many UCC products that are helping aviation reach new heights.

STUDENTS and STUDENT ADVISERS: *Learn more about the many fields in which Union Carbide offers career opportunities. Write for the free illustrated booklet "Products and Processes" which describes the various activities of UCC in the fields of* ALLOYS, CARBONS, CHEMICALS, GASES, *and* PLASTICS. *Ask for booklet C-2.*

UNION CARBIDE
AND CARBON CORPORATION
30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

UCC's Trade-marked Products of Alloys, Carbons, Chemicals, Gases, and Plastics include

NATIONAL Carbons • ACHESON Electrodes • EVEREADY Flashlights and Batteries • PRESTONE and TREK Anti-Freezes
ELECTROMET Alloys and Metals • HAYNES STELLITE Alloys • PREST-O-LITE Acetylene • PYROFAX Gas
DYNEL Textile Fibers • BAKELITE, KRENE, and VINYLITE Plastics • LINDE Oxygen • SYNTHETIC ORGANIC CHEMICALS

THE DU PONT DIGEST

DU PONT SCIENCE AND ENGINEERING GRADUATES MEET THE PUBLIC IN

Technical Sales

James A. Newman, *B. S. in Ch. E., North Carolina State '40, discusses study of optimum settings and conditions for carding nylon staple with Prof. J. F. Bogdan of North Carolina State's Research Division.*

More and more, industry is on the lookout for technically trained men and science majors who have an interest in and aptitude for selling. A number of departments at Du Pont prefer men with such training for sales positions. A technical understanding of the properties of a substance helps a man do a better selling job—and offers the customer better service.

Because of the diverse applications of Du Pont's many products, there is a need for sales representatives with widely varying technical backgrounds. There are problems involving chemistry and many types of engineering in such fields as plastics, ceramics, textiles and many others.

Technical men may work in direct sales, sales service, or sales development groups, depending on departmental organization. In some cases technical men handle all phases of selling. In others they deal mainly with customer problems. Some departments also maintain a sales development section that works on technical problems connected with the introduction of a new product or a new application for an established one.

Ivan R. Smith, *B.S. in Ch.E., Kansas State University '40 (right), advises the operator of a galvanizing machine on the efficient use of a Du Pont flux.*

Edgar G. Boyce, *Ashland State (right), helps a customer improve his method of applying silicate adhesive in the manufacture of corrugated boxboard.*

Here are examples of the kind of problems attacked by technical men in Du Pont sales groups:

1. Find a more economical way to apply sodium silicate used in making corrugated paperboard. Du Pont men, as in many other instances, were able to make substantial savings for the customer.

2. Introduce fabrics of "Orlon" acrylic fiber for use in dust filtration. This involved evaluation and modification of filter fabrics in cooperation with makers of dust-control equipment, and with plant personnel having serious dust-recovery problems.

3. Reduce the time needed for processing motion-picture film used by race tracks. Technical service men carried the problem to a research group which developed an emulsion that could be processed in about one-third the former time.

Technical men interested in sales work at Du Pont usually acquire needed background in a laboratory or manufacturing plant. Depending on their interest and abilities, they may then move into technical sales service, sales development, or direct sales.

In any of these fields, the man with the right combination of sales ability and technical knowledge will find not only interesting work but exceptional opportunities for growth in the Company.

College graduates with many types of technical training find opportunities at Du Pont. Write for your copy of "The Du Pont Company and the College Graduate." Address: E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.

DU PONT

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Entertaining, Informative—
See "Cavalcade of America" on Television

ME...
an AIRCRAFT engineer?

But I haven't majored in aeronautical engineering

That doesn't matter. Lockheed can train you... at full pay!

It's your aptitude, your knowledge of engineering principles, your degree in engineering that count.

Those—plus the opportunity Lockheed is offering you—are all you need for a career as an aircraft engineer. In Lockheed's special program for engineering graduates, you may go back to school, or you may convert to aircraft work by doing—on-the-job training. But whichever it is, you receive full pay while learning.

But Lockheed offers you more than a career. It offers you a new life, in an area where living conditions are beyond compare. Outdoor living prevails the year-'round. Mountains, beaches are an hour from Lockheed.

See your Placement Officer today for the details on Lockheed's Aircraft Training Program for engineers, as well as the better living conditions in Southern California.

If your Placement Officer is out of the illustrated brochures describing living and working conditions at Lockheed, write M. V. Mattson, Employment Manager

Lockheed Aircraft Corporation
Burbank, California

This Plane made History

The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

This Plane is making History

The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

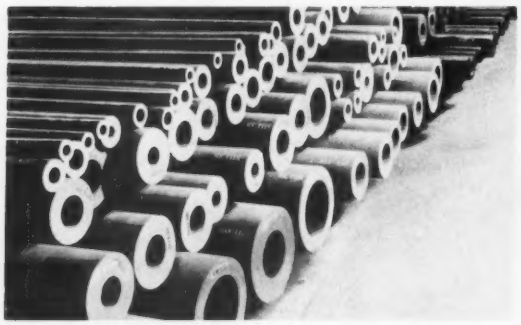
This Plane will make History

This plane – which exists only in the brain of an engineer like yourself – is one reason there's a better future for you at Lockheed. For Lockheed will always need engineers with ideas, engineers with imagination, engineers who build the planes that make history.

What's Happening at CRUCIBLE

about hollow tool steel

Crucible is now making its high quality tool steel available in hollow form. Bars of Crucible Hollow Tool Steel can now be obtained with machine finished inside and outside diameters and faces — in three famous grades: KETOS, AIRDI 150 and SANDERSON. Already its use has effected substantial savings for makers of tool steel parts with cutout centers.



typical applications

The ring shaped tools that can be fabricated from hollow tool steel are virtually limitless — beading rolls, bearings and bushings, blanking and briquetting dies, cam dies and followers, chuck jaws, circular knives and shears, cutters, die holders and inserts, engraver and edging rolls, extrusion dies, feed and flue rollers, forming rolls, nozzles, saws, sleeves, slitters, stamping dies, wheels . . . and many others.

how it cuts costs

Crucible Hollow Tool Steel permits a toolmaker to bypass drilling, boring, cutting off and rough facing operations. Naturally, this results in less production time per unit, greater machine capacity, and a reduction in scrap losses. In some cases material costs alone are cut 20% by the use of Crucible Hollow Tool Steel instead of regular bar stock.

availability

All grades and sizes of Crucible Hollow Tool Steel are carried in stock in Crucible warehouses conveniently located throughout the country.

CRUCIBLE HOLLOW TOOL STEEL

Sizes (inches)	GRADES		
	Sanderson	Ketos	Airdi 150
2 O.D. x 1 I.D.	x	x	
2½ O.D. x 1½ I.D.		x	
3 O.D. x 1½ I.D.		x	
3¼ O.D. x 1¼ I.D.	x	x	x
3¼ O.D. x 1½ I.D.		x	
3½ O.D. x 1½ I.D.	x		
3½ O.D. x 2 I.D.	x	x	x
4 O.D. x 1½ I.D.			x
4 O.D. x 2 I.D.		x	x
4¼ O.D. x 1¾ I.D.			x
4½ O.D. x 2 I.D.	x		x
5 O.D. x 2 I.D.	x	x	x
5 O.D. x 2½ I.D.		x	x
5 O.D. x 3 I.D.	x	x	
5½ O.D. x 1¾ I.D.			x
5½ O.D. x 2 I.D.		x	
5½ O.D. x 2½ I.D.	x		x
6 O.D. x 1¾ I.D.			x
6 O.D. x 2 I.D.		x	
6 O.D. x 3 I.D.	x	x	x
6½ O.D. x 3¼ I.D.			x
6½ O.D. x 3½ I.D.		x	
6½ O.D. x 4 I.D.			x
7 O.D. x 2¼ I.D.			x
7 O.D. x 3 I.D.	x	x	
7 O.D. x 3½ I.D.			x
7 O.D. x 4 I.D.	x	x	
7½ O.D. x 3 I.D.	x	x	
7½ O.D. x 3½ I.D.	x	x	
7½ O.D. x 4 I.D.			x
8 O.D. x 3½ I.D.	x	x	
8 O.D. x 5 I.D.	x	x	x
8¼ O.D. x 3½ I.D.			x
8½ O.D. x 5¼ I.D.	x	x	x
9 O.D. x 4 I.D.	x	x	
9 O.D. x 5 I.D.		x	x
9 O.D. x 6 I.D.	x		
10 O.D. x 4 I.D.		x	
10 O.D. x 5 I.D.	x	x	
10 O.D. x 6 I.D.	x	x	x
11 O.D. x 4 I.D.	x	x	
11 O.D. x 6 O.D.	x	x	
11 O.D. x 7 I.D.		x	x
12 O.D. x 5 I.D.	x	x	x
12 O.D. x 6 I.D.	x	x	
12 O.D. x 7 I.D.	x	x	
12 O.D. x 8 I.D.		x	
13 O.D. x 6 I.D.		x	x
13 O.D. x 7 I.D.	x	x	
13 O.D. x 8 I.D.			x
13 O.D. x 9 I.D.		x	
14 O.D. x 7 I.D.	x	x	x
14 O.D. x 10 I.D.		x	
15 O.D. x 9 I.D.		x	x
15 O.D. x 10 I.D.		x	
16 O.D. x 10 I.D.	x	x	x
16 O.D. x 12 I.D.	x	x	

technical service

If you make tools with machined-out centers and wish additional information on Crucible Hollow Tool Steel, or technical assistance in solving an application problem, call in a Crucible representative. Our experienced staff of tool steel specialists is always available.

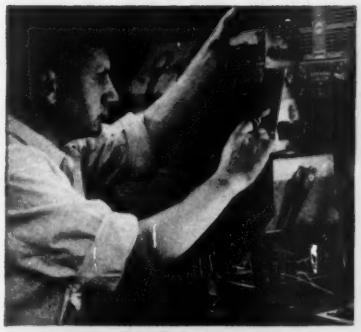
CRUCIBLE **first name in special purpose steels**

53 years of Fine steelmaking

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa.
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

Opportunity for engineers keeps on growing in Honeywell's Heating Controls Division



Helping keep freedom alive is certainly an unusual task for a Honeywell thermostat.

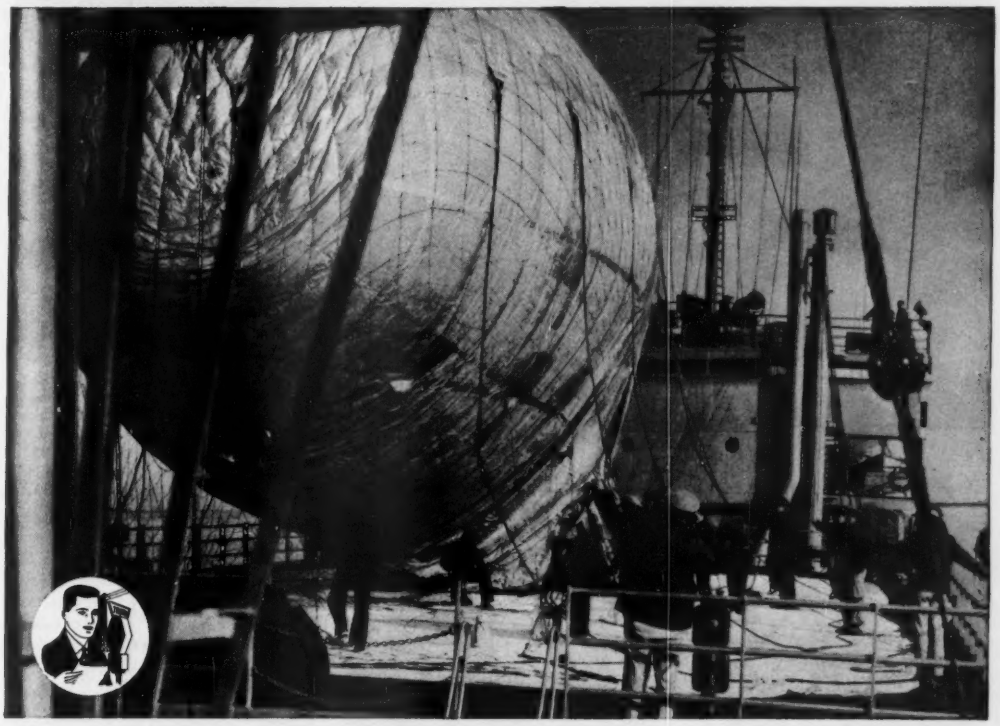
Part of the story concerns the U.S. coastguardsmen below. They're hoisting the balloon that carries the antenna aloft aboard the *Courier*. This Voice of America radio ship is used to outwit Soviet jamming and improve radio penetration of the Iron Curtain.

The Honeywell part of the story concerns the *Courier's* powerful transmitters. When operating, these transmitters generate a great deal of heat. This would often make the radio room unbearably hot—if it were not for a special air conditioning system with controls designed by Honeywell.

This unusual application is just one indication of to what degree Honeywell temperature controls have become an integral part of the 20th century industrial revolution. The demand for these controls continues to grow. And in developing these new controls, the men in our expanding engineering and research sections often find their work calls for fascinating study in the realm of pure science.

Yes, opportunities for engineers keep pace at Honeywell—for this *is* the age of Antomatic Control.

And Honeywell has been the *leader* in controls for more than 60 years.



The world lives better—works better—with Honeywell Controls

MINNEAPOLIS **Honeywell**

First in Controls

SEND COUPON FOR MORE INFORMATION

MINNEAPOLIS-HONEYWELL REGULATOR CO.
Personnel Dept., Minneapolis 8, Minnesota

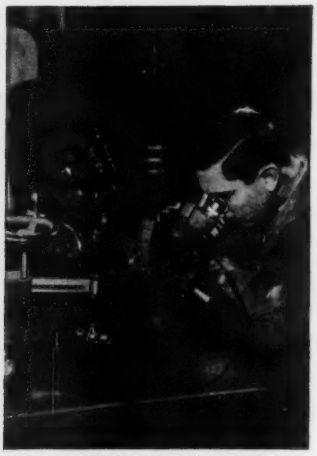
Gentlemen: Please send me your booklet, "Emphasis on Research", which tells more about engineering opportunities at Honeywell.

Name _____

Address _____

City _____ *Zone* ____ *State* _____

The New Norton G Bond. The grinding wheel this man is using — in a Norton grinding machine — is made with the new Norton G Bond, one of the most important grinding wheel achievements in 45 years. The G Bond is a special vitrified bond, developed by Norton research engineers, that gives greatly improved grinding performance in many precision and semi-precision jobs — typical of the "Touch of Gold" that Norton brings to *all* grinding.



Helping To Produce The G Bond, Roderic C. Lancy, M.S., Ch.E., a recent graduate of Worcester Polytechnic Institute, examines bond particles under a stereoscopic microscope in the Norton research laboratories.

How modern grinding gets the

"TOUCH OF GOLD"

Ever consider how grinding with exactly the right wheel literally gives shop men the "Touch of Gold?"

That's because every time a top-performing grinding wheel touches the work, value is being added. At the same time the manufacturer is cutting costs and increasing profit-margins . . . while the ultimate purchaser of the product itself is getting more for his money.

Norton grinding wheels have top performance "engineered in." And as the world's largest producers in the abrasive field, Norton is always able to furnish the right abrasive or abrasive product for every job — thus supplying countless workers throughout industry with the true value-adding, cost-cutting "Touch of Gold."

Your Future with Norton

As industry expands, the demand for Norton products naturally increases, in a constantly growing list of grinding, polishing and other abrasive applications. A career with Norton — making better products to make other products better — offers steadily increasing opportunities for personal progress. But wherever your career in industry may take you, you will find the Norton "Touch of Gold" an invaluable aid to better production.

NORTON

Making better products to make other products better

Abrasives • Grinding Wheels • Pulpstones • Oilstones
Abrasive Paper and Cloth • Grinding and Lapping Machines • Non-Slip Flooring • Refractories • Boron Carbide Products

NORTON COMPANY
WORCESTER 6, MASSACHUSETTS

Behr-Manning, Troy, N. Y., Is A Division of Norton Company

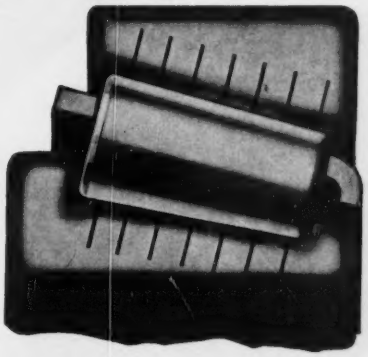
Another page for **YOUR BEARING NOTEBOOK**

How to give an 8-speed miller greater spindle accuracy

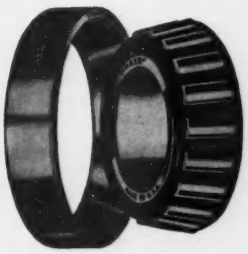
This milling machine has 8 speeds, from 62 to 2870 RPM. To hold the spindle in accurate alignment at these various speeds, design engineers mount it on Timken® precision bearings. Long-lasting milling precision is assured. Spindle accuracy can be controlled because Timken bearings are adjustable. And they provide more than enough capacity for any tool load.

Line contact of TIMKEN® bearings keeps spindles rigid

Because Timken bearings carry the load along the line of contact between rollers and races, they give a wider, more rigid support to the shaft. And the tapered construction of Timken bearings enables them to take radial and thrust loads in any combination. End-play and deflection in the shaft are practically eliminated.



TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS



Want to learn more about bearings or job opportunities?

Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken Bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⊕ AND THRUST ⊖ LOADS OR ANY COMBINATION ✣

PHOTOGRAPHY AT WORK No. 2 in a series:

YOUR IDEAS

Will Keep Planes Like This On The American Team

What makes great planes like North American Aviation's F-86D and sister *Sabre* jets? The answer is new ideas . . . young ideas. And just as the ideas of young engineers of a decade past helped perfect the plane you see above, so will the ideas of today's engineering students—your ideas—perfect tomorrow's F-???. That's why North American Aviation always has challenging career opportunities for bright, young graduate engineers.

Today, North American is developing projects of a new era—aircraft, guided missles, rocket engines, rockets, electronics, atomic energy. If you'd enjoy the challenge of pioneering in these advanced fields, consider looking to the future with North American when you complete your engineering training. In the meantime, feel free to write for information concerning a career in the aircraft industry.

Your student placement office will be glad to supply you with more detailed information. Or if you prefer, write direct, including your name, address, placement preference and personal data. Please address your reply to:

D. R. Zook, Employment Director, 5701 W. Imperial Highway, Los Angeles

NORTH AMERICAN AVIATION, INC.

Los Angeles, California • Columbus, Ohio

NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD

PHOTOGRAPHY AT WORK No. 2 in a series:

Knitting mill solves help shortage, attracts and keeps full staff

Hand Knit Hosiery Company of Sheboygan, Wisc., knitters of Wigwam Socks, found many potential employees resisted jobs simply because they didn't know the sort of opportunities offered.

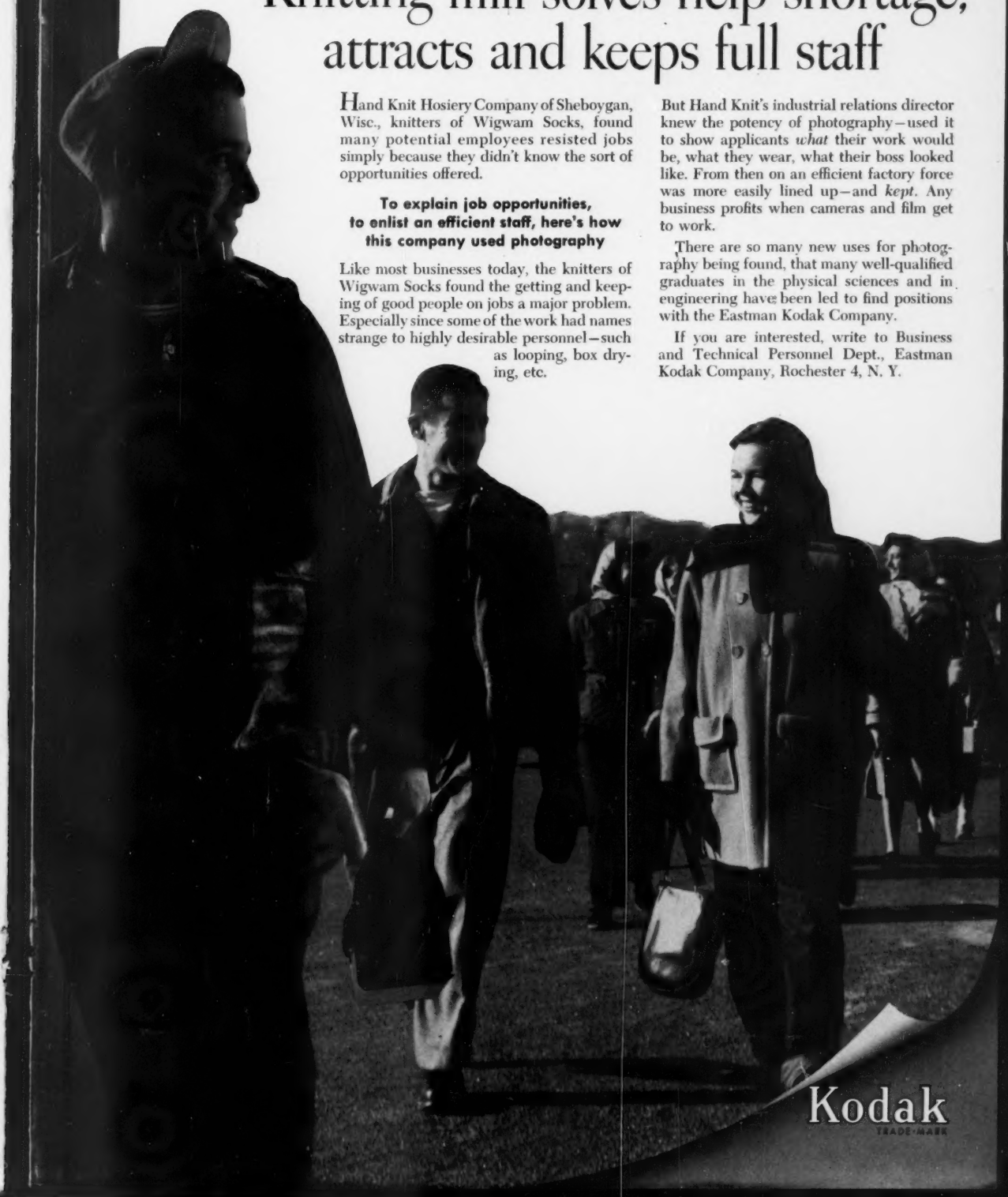
To explain job opportunities, to enlist an efficient staff, here's how this company used photography

Like most businesses today, the knitters of Wigwam Socks found the getting and keeping of good people on jobs a major problem. Especially since some of the work had names strange to highly desirable personnel—such as looping, box drying, etc.

But Hand Knit's industrial relations director knew the potency of photography—used it to show applicants *what* their work would be, what they wear, what their boss looked like. From then on an efficient factory force was more easily lined up—and *kept*. Any business profits when cameras and film get to work.

There are so many new uses for photography being found, that many well-qualified graduates in the physical sciences and in engineering have been led to find positions with the Eastman Kodak Company.

If you are interested, write to Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.



Kodak
TRADE-MARK

6 WAYS TO BEGIN A SUCCESSFUL CAREER

TEST ENGINEERING PROGRAM—offers engineering graduates opportunities for careers not only in engineering but in all phases of the Company's business. Includes rotating assignments plus opportunities for classroom study.

BUSINESS TRAINING PROGRAM—open to business administration, liberal arts, and other graduates . . . for careers in accounting, finance, administration, and other fields. Includes on-the-job training plus classroom study.

CHEMICAL AND METALLURGICAL PROGRAM—provides rotational assignments in chemistry, chemical engineering, and metallurgy. Also offers graduate-level courses stressing solution of practical engineering problems through application of basic principles of physical chemistry and unit operations.

MANUFACTURING TRAINING PROGRAM—for developing leaders in the field of manufacturing. Open to graduates with a technical education or a general education with technical emphasis.

ADVERTISING TRAINING COURSE—offers graduates career opportunities in all phases of advertising, sales promotion, and public relations work. Includes on-the-job training and a complete classwork program.

PHYSICS PROGRAM—offers physicists rotating assignments in applied research in many fields of physics plus ample opportunity for organized classroom study. Program graduates have gone into such fields as research, development, manufacturing, design, marketing.

FEW companies can offer as broad a range of career opportunities as General Electric. Whether a young man is interested in science or engineering, physics or chemistry, electronics or atomic energy, plastics or air conditioning, accounting or sales, employee relations or advertising, drafting or jet engines . . . he can plan for himself a G-E career.

The training programs summarized here are only a few of the "open doorways" that lead to successful careers in a company where big and important jobs are being done, and where young people of vision and courage are needed to help do them.

If you are interested in building a G-E career after graduation, talk with your placement officer and the G-E representative when he visits your campus. Meanwhile, for further information write to College Editor, Dept., 2-123, General Electric Co., Schenectady 5, New York.

You can put your confidence in—

GENERAL ELECTRIC

THIS PUBLICATION IS REPRODUCED BY AGREEMENT WITH THE COPYRIGHT OWNER. EXTENSIVE DUPLICATION OR RESALE WITHOUT PERMISSION IS PROHIBITED.